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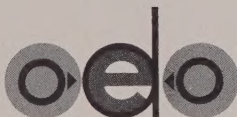
T. O. 33A1-12-440-3

TECHNICAL MANUAL

OVERHAUL INSTRUCTIONS

# PHASEMETER ASSEMBLY

MODEL 901/1010



from a habit of quality . . . a record of reliability

**ELECTRONIC DESIGNS**

2311 FARRINGTON • DALLAS 7, TEXAS • MELROSE 1-0240  
A DIVISION OF SCIENCE-METRICS CORPORATION

15 FEBRUARY 1964



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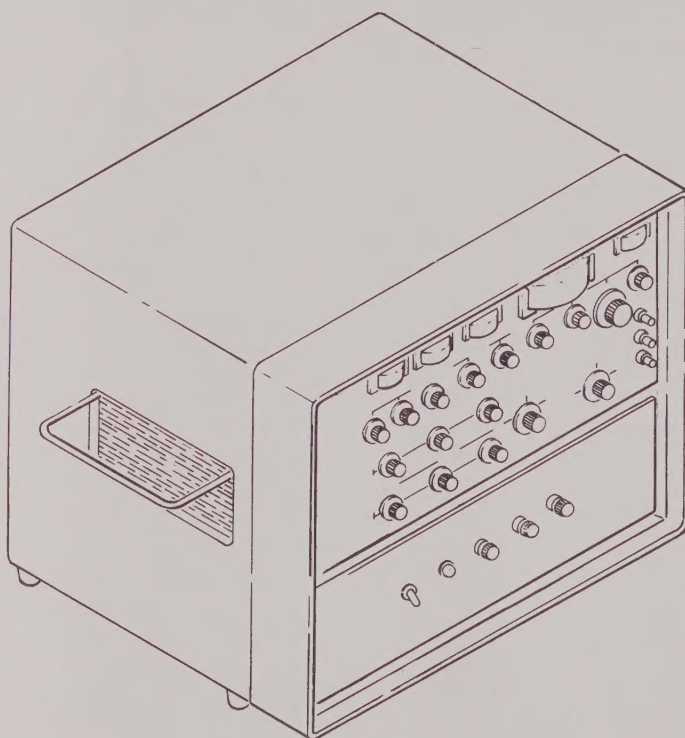
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## INTRODUCTION

The purpose of this manual is to provide overhaul instructions and procedures as recommended by the manufacturer of the equipment.

The information contained in this manual has been prepared in accordance with the following specifications: Military Standard Electrical and Electronic Symbols, MIL-STD-15A; Air Force - Navy Aeronautical Bulletin; Abbreviations and Contractions, MIL-STD-12A.



## SECTION I

## DESCRIPTION AND LEADING PARTICULARS

## 1-1. GENERAL.

1-2. This manual comprises overhaul instructions for the Phasemeter, Model 901/1010 manufactured by Electronic Designs Division of Maxson Electronic Corp., Dallas, Texas, under contract number AF04(607)-6403.

## 1-3. PURPOSE OF EQUIPMENT.

1-4. The Model 901/1010 Phasemeter is a phase-measuring device for use in measurement of phase differences between two sinusoidal audio frequency input voltages.

## 1-5. DESCRIPTION.

1-6. The phasemeter is a highly accurate phase-measuring device capable of an accuracy of 0.1 degree (0.01 degree incremental accuracy). The phase meter contains two separate chassis electrically interconnected in a single case to facilitate servicing and maintenance of the equipment. The phase meter chassis is mounted on the top rack in the case and the power supply unit in on the bottom rack.

1-7. Phase comparison is accomplished by a detector consisting of four semiconductor diodes arranged as a ring modulator. Phase is correlated to voltage and phase difference is read directly from a precision voltage divider which controls the amount of quadrature voltage added to a reference signal voltage. A calibrated null indicating meter provides resolution up to 0.01 degree.

## 1-8. PRINCIPLES OF OPERATION.

## 1-9. GENERAL.

1-10. The phase meter consists of two signal channels, terminating in a phase detector which indicates approximate phase quadrature between its input signals (figure 1-2). Two phase shifters, one calibrated and the other uncalibrated, are inserted in series with one of the channels. Either phase shifter can modify the phase difference between signals at the phase detector input as compared with those at the phase meter input.

1-11. The phasemeter comprises the Input Follower Unit (D100054), the 90-Degree Amplifier Unit (D100055), the VTVM Unit (D72935), the Unknown Amplifier Unit (D100065), the Sense Detector Unit

(D72891), the Adder and Phase Shifter Unit (D100062), the Reference Amplifier Unit (D100064), and a precisely calibrated potentiometer assembly (Z801). Refer to figure 1-3.

1-12. The two input signals whose phase difference is to be measured are respectively applied to the REFERENCE and UNKNOWN INPUT terminals. PHASE-CALIBRATE switch S802 determines which of the input signals is fed into each of the channels. When the PHASE-CALIBRATE switch is in the CALIBRATE position, the signal applied to the REFERENCE INPUT terminal is fed to both channels to permit calibration of the phasemeter.

1-13. With the PHASE-CALIBRATE switch in the PHASE-LEAD position, the signal applied to the REFERENCE INPUT terminal is fed through an isolating cathode follower to the 90-Degree Amplifier; the signal applied to the UNKNOWN INPUT terminal is fed through an isolating cathode follower to the Unknown Channel Amplifier. When the PHASE CALIBRATE switch is operated to the PHASE-LAG position, the paths of the input signals are interchanged.

1-14. The 90-Degree Amplifier Unit is an amplifier which produces exactly unity gain and exactly 90 degrees of phase shift at its output. By the subsequent addition of properly chosen amounts of the input and output voltages of the 90-Degree Amplifier, a resultant signal can be produced having any phase shift between zero and 90 degrees. The input and output voltages of the 90-Degree Amplifier Unit are fed through potentiometer assembly Z801 and PHASE-CALIBRATE switch S802 to the inputs of the Adder and Phase Shifter Unit. Depending upon the setting of Z801, one of these voltages is attenuated by the precisely calibrated potentiometer of Z801; the other is applied directly to the Adder and Phase Shifter Unit.

1-15. The Adder and Phase Shifter Unit comprises two identical amplifier channels and an adding circuit. The addition results in an output signal which has a phase angle between zero and 90 degrees, as determined by potentiometer assembly Z801. The output of the Adder and Phase Shifter Unit is fed to the uncalibrated phase shifter. The uncalibrated phase shifter comprises a circuit in which a balanced voltage is connected across a series combination of a capacitor and a variable resistor. When R and X are equal, a shift of 90 degrees is produced. For other resistance values different output phases result; however, the amplitude remains constant.

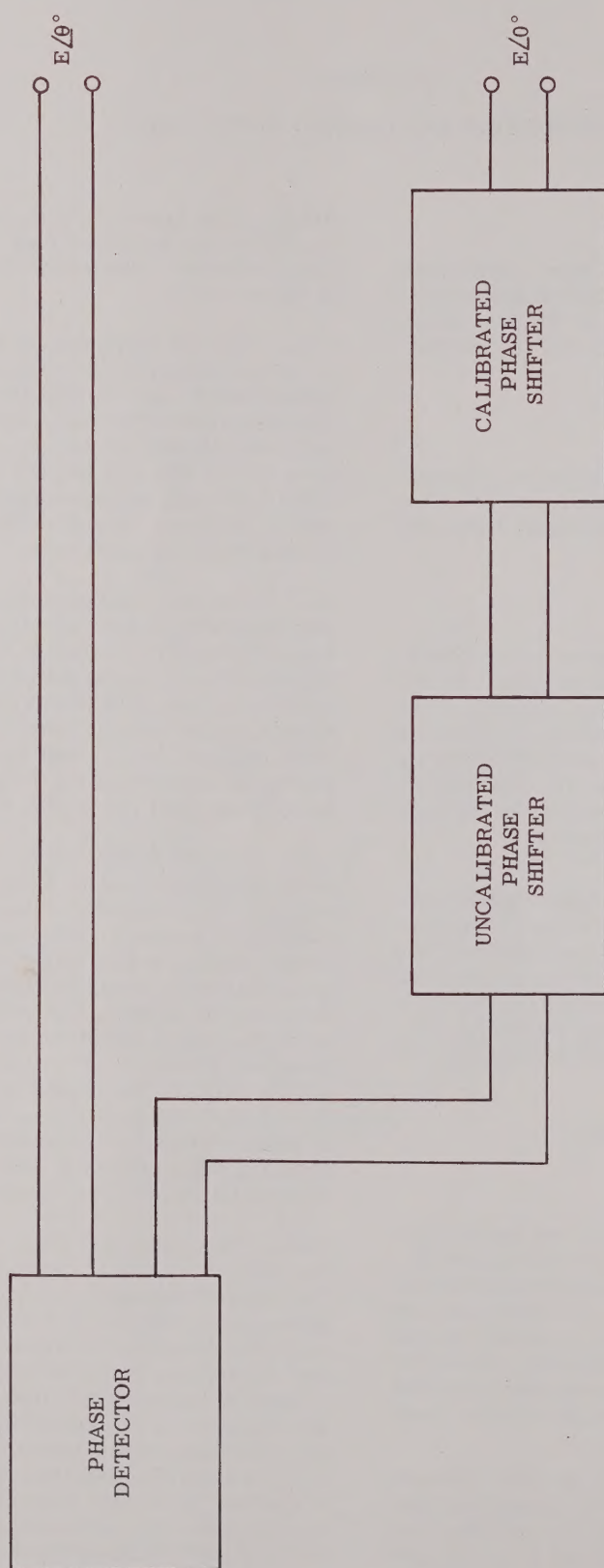


Figure 1-2. Functional Block Diagram

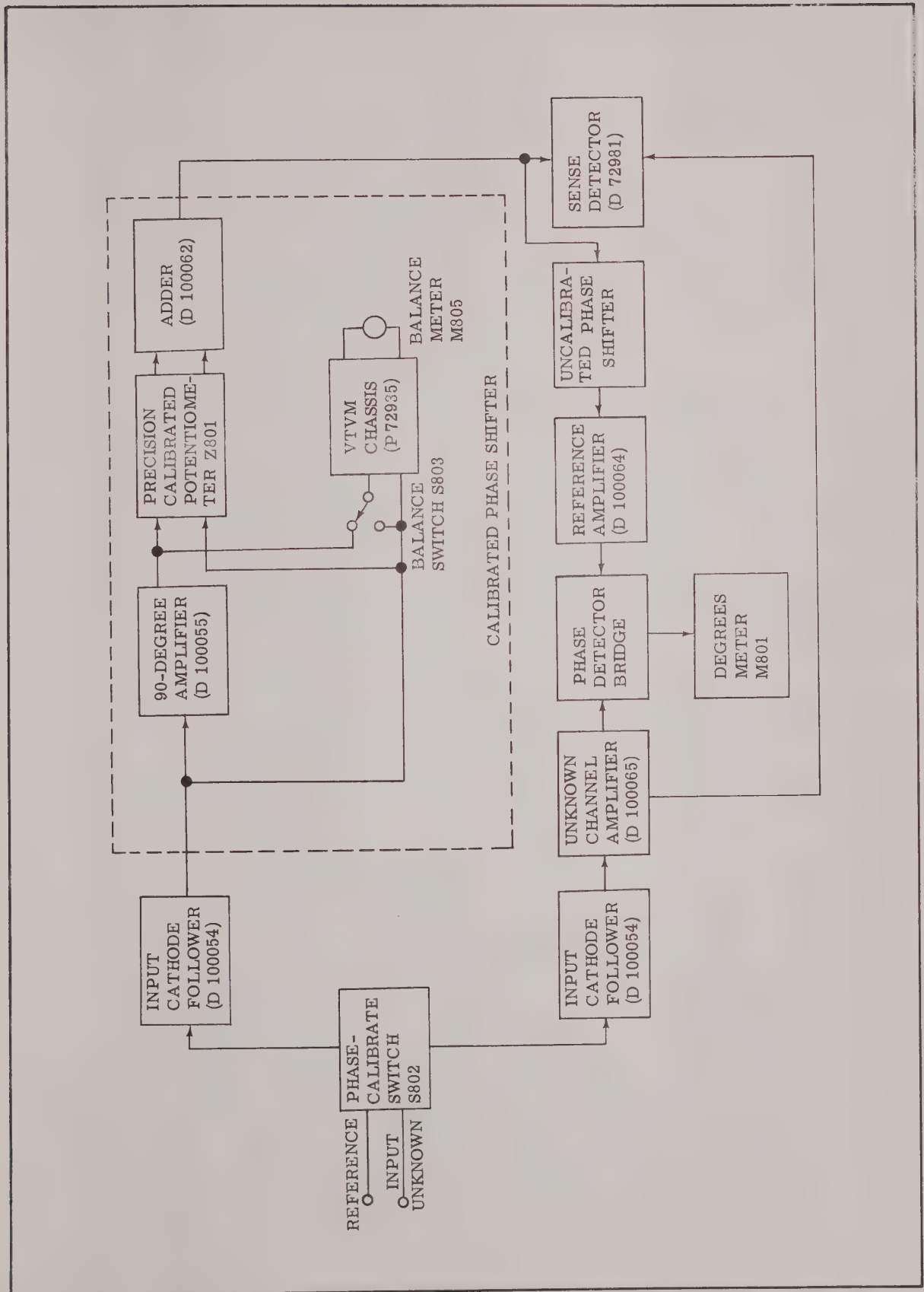


Figure 1-3. Detail Block Diagram

1-16. The output of the uncalibrated phase shifter is fed to the Reference Amplifier Unit. This amplifier is a highly stabilized feedback amplifier whose output is fed to the phase detector bridge. The other input to the phase detector bridge is the signal applied to the Unknown Amplifier Unit. The Unknown Amplifier Unit is also a highly stabilized feedback amplifier.

1-17. The phase detector circuit consists of a diode bridge arranged in the common wattmeter circuit or ring modulator. This bridge produces a null when its two input signals are in quadrature. The bridge is used to drive the zero-center DEGREES meter M801, which is capable of being read to 0.01 degree on a plus or minus one degree scale.

1-18. The VTVM Unit is used to adjust the calibration of the 90-Degree Amplifier. The VTVM circuit is balanced by feeding the same signal into both input channels (accomplished by operating the BALANCE switch to the ZERO position) and adjusting the BALANCE ZERO and SET controls to zero BALANCE meter M805. When the VTVM circuit has been balanced, it will detect an amplitude deviation between the input and output voltages of the 90-Degree Amplifier Unit of one part in 3000. This is equivalent to approximately 0.01 degree at the 45-degree point. The VTVM Unit consists of two similar stabilized feedback amplifiers and detectors driving a zero-center microammeter.

1-19. The Sense Detector Unit comprises two separate amplifier channels, a diode bridge, and an indicating microammeter. One input to this chassis is derived from the input to the Unknown Amplifier Unit. The other input is obtained from the output of the Adder and Phase Shifter Unit. Each input is separately amplified and applied to the diode bridge. The bridge actuates a microammeter which indicates whether the absolute value of the phase difference between the two signals applied to the phasemeter is less than 90 degrees (ADD 0°) or greater than 90 degrees (ADD 180°). A switch is used to adjust the polarity of the unknown channel signal applied to the phase detector bridge in accordance with this meter reading. The Power Supply Chassis comprises an electronically regulated supply providing +250 volts.

#### 1-20. DETAILED THEORY OF OPERATION.

1-21. Input Circuits. The signals whose phase difference is to be measured are fed respectively to the REFERENCE and UNKNOWN INPUT terminals. These terminals are connected to PHASE-CALIBRATE switch S802. When S802 is in the PHASE-LEAD position, the signal applied to the REFERENCE terminal is fed to the grid of the reference channel cathode follower input stage V401. The signal applied to the

UNKNOWN terminal is fed to the grid of the unknown channel cathode follower input stage. Both cathode followers are identical and are described in detail below.

1-22. When S802 is operated to the PHASE-LAG position, the signal applied to the REFERENCE terminal is fed to the unknown channel; the signal applied to the UNKNOWN terminal is fed to the reference channel. Thus, the signal flow with S802 in the PHASE-LAG position is the reverse of the signal flow with S802 in the PHASE-LEAD position.

1-23. When S802 is operated to the CALIBRATE position, the signal applied to the REFERENCE terminal is fed to both channels. This is done to permit calibration of the phasemeter.

1-24. Input Follower. (See figure 1-4.) This unit comprises two 12AT7WA tubes V401 and V402, which are respectively the input cathode follower tubes for the reference channel and the unknown channel. Both cathode followers are identical. The input signal is applied to the grid of each tube through a one-k resistor. The tube is self-biased and acts as a matching and isolating circuit for the channel input signal. The cathode load is a potentiometer which is used to adjust the signal level applied to the subsequent circuits. All connections to the Input Follower Assembly except the two signal input leads, are made through J401 which mates with P401. (See figure 1-5.)

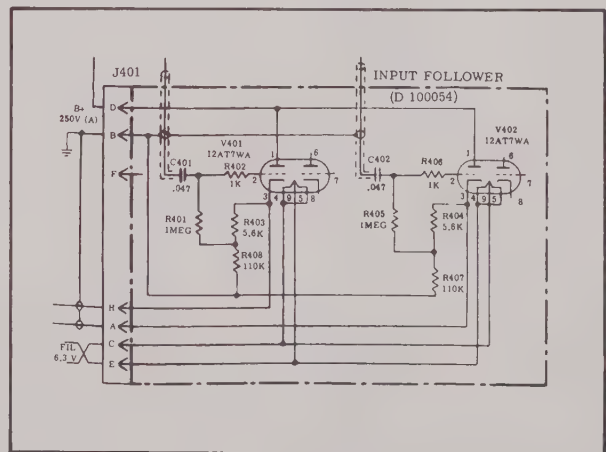
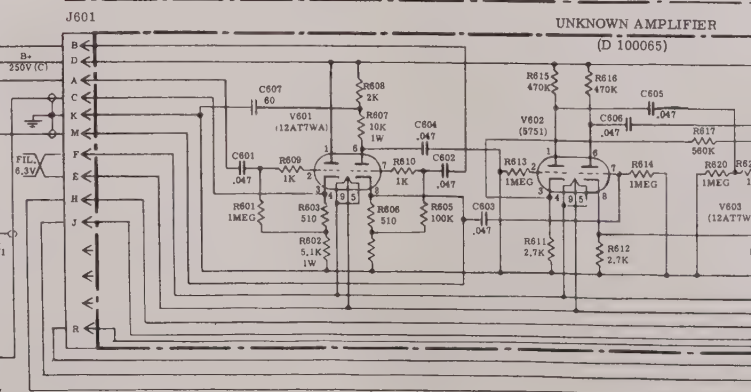


Figure 1-4. Input Follower Schematic

1-25. 90-Degree Amplifier Unit. (See figure 1-6.) The 90-Degree Amplifier is basically a feedback amplifier which has unity gain when the reactance of C is equal to R. It produces a 90-degree phase shift by means of the very large increase in the effective value of C produced by the feedback. The deviation from 90 degrees, with R and C adjusted for unity gain, is approximately equal to  $1/G$  radians, where G is the open-loop amplifier gain. Thus, an amplifier gain of 3000 results in a deviation from 90 degrees of only approximately 0.02 degree.





1-5



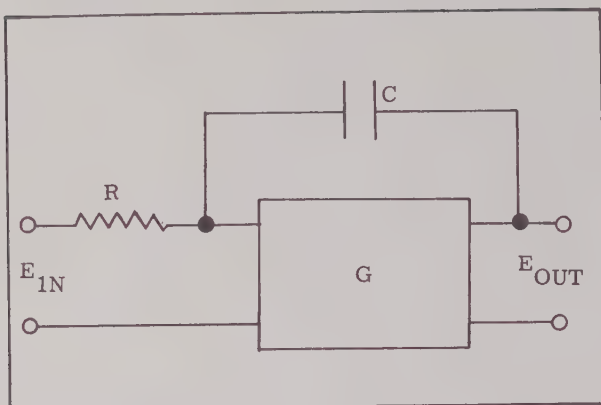


Figure 1-6. Simplified Diagram, 90-Degree Amplifier

1-26. The signal from REFERENCE LEVEL potentiometer R806 is applied to the input of the cathode follower formed by the left half of V501. The signal then goes through the high-pass filter formed by R506 and, depending upon the frequency band being used, through either C804, C805, or C806 and R825. This high-pass filter is necessitated by the fact that the gain of the subsequent feedback amplifier is high for signals below the frequency being used.

1-27. The signal then goes through the cathode follower formed by the right half of V501, and is then applied through R812, R813, R814, R815, and R816 to the grid of V502. (These resistors correspond to resistance R of figure 1-7.) V502 and V503 provide the necessary high-gain amplification.

1-28. Resistor R511 and capacitor C504 form a "cornering" network to prevent low-frequency instability. Voltage Regulator V506 acts as a direct coupling element from V503 to output cathode followers V504 and V505. If V503 is removed from its

socket, neon lamp I501 ignites, limiting the d-c voltage applied to the grids of V504 and V505. This protects precision voltage divider Z801 from overload, since this divider serves as the cathode load of these tubes.

1-29. Output cathode followers V504 and V505 provide an output of very low impedance, and thus render the 90-Degree Amplifier insensitive to variations in output loading. The feedback path is provided from the cathodes of V504 and V505 to the grid of V502 by either C813, C814, or C815, depending upon the frequency band being used and the corresponding setting of FREQUENCY MULTIPLIER switch S804. These three capacitors possess extremely low dissipation factors, since any residual leakage resistance causes an error in the 90-degree phase shift produced by the amplifier.

1-30. The BALANCE COARSE (R812), MEDIUM (R814) and FINE (R816) controls are adjusted to achieve unity gain at the frequency of operation.

1-31. The connection from the junction of R812 and the feedback capacitor to the grid of V502 is made through a tip jack in order to minimize stray coupling with other circuits. All other connections to the 90-Degree Amplifier Unit are made through connector J501, which mates with P501.

1-32. VTVM UNIT. (See figure 1-8.)

1-33. The VTVM Unit, in conjunction with BALANCE meter M805, compares the amplitudes of the input and output signals of the 90-Degree Amplifier.

1-34. During operation, the BALANCE COMPARE switch S803 is set to COMPARE. The 90-Degree Amplifier input signal, taken from pin 8 of V501, is then applied to one channel of the VTVM circuit,

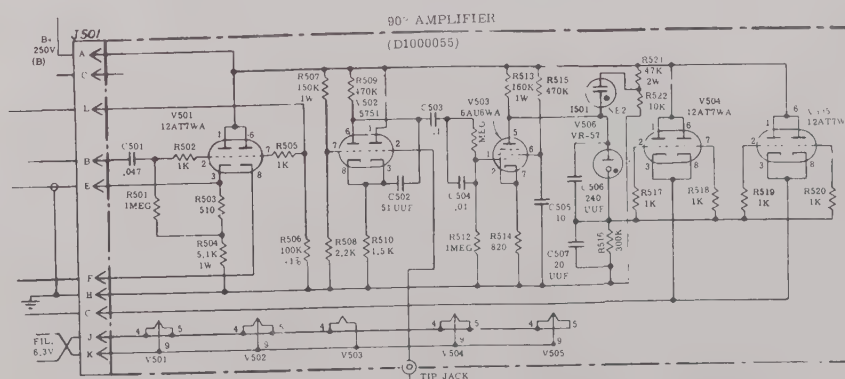


Figure 1-7. 90-Degree Amplifier Schematic

1-41. For settings of the DEGREES knob from 46 to 90 degrees, the reference (90-Degree Amplifier input) signal is connected across the voltage divider, while the quadrature (90-Degree Amplifier output) signal is connected across the fixed resistor. This permits the generation of resultant phase angles between 45 and 90 degrees when the two signals are added.



1-42. Adder and Phase Shifter Unit. (See figure 1-9.) The reference and quadrature signals from precision voltage divider assembly Z801 are applied to terminals A and C of J301. (When switch S802 is set at CALIBRATE, the reference signal at full amplitude is applied to terminal A, while terminal C is grounded.

1-43. The adder consists of two unity-gain feedback amplifiers feeding a pair of matched resistors. The signal applied to input terminal A is amplified in both halves of V301 and is then fed to cathode follower V302. The heavy negative feedback provided by the common cathode connection of V301 and V302 is necessary to insure addition with phase accuracy better than 0.01 degree and amplitude accuracy of one part in 3,000. The amplifier output impedance is less than one ohm and the effects of vacuum tube variations and component aging are virtually eliminated.

1-44. Tubes V303 and V304 comprise an identical feedback amplifier for the signal applied to terminal C of J301. R315A and R315B are respectively the output loads of the two feedback amplifiers, and are precision wirewound units matched to within 0.01 percent.

1-45. The signals from the two amplifiers are added across R317 and amplified in the first half of V305. A portion of the signal at the plate of this tube is picked off to form one of the inputs to the Sense Detector Unit. The second half of V305 is a phase splitter which provides a push-pull input for dual cathode follower V306. The output signals from V306, which are 180 degrees out of phase with each other, are applied to the uncalibrated variable phase shifter.

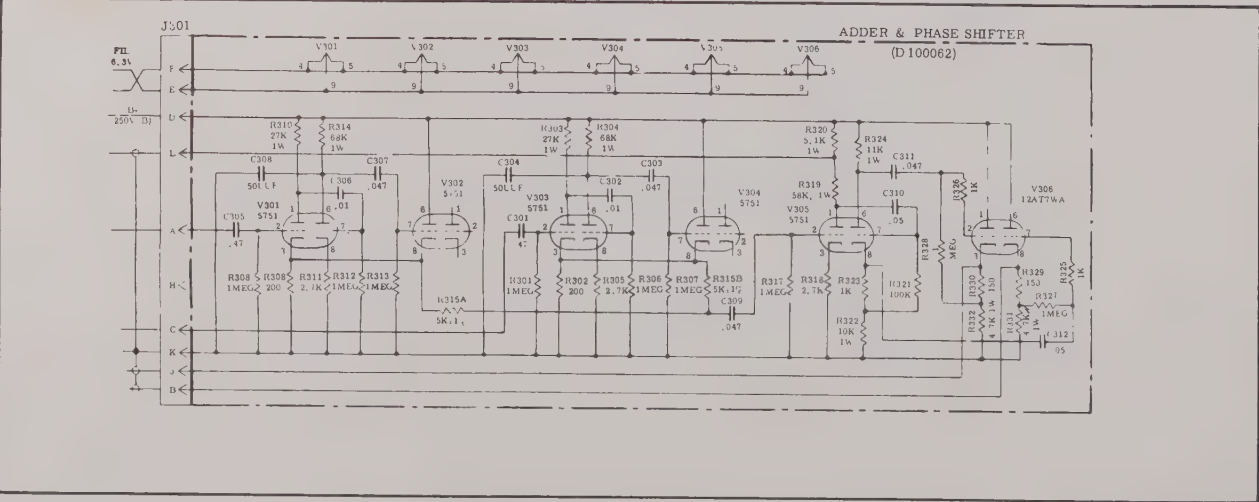
1-46. A basic circuit diagram of the uncalibrated phase shifter is shown in figure 1-10. The input signals, which are of equal amplitude E and 180 degrees out of phase with one another, are taken

from the cathodes of V306. Depending upon the position of frequency MULTIPLIER switch S804, capacitance C consists of either C810, C811, or C812. Resistance comprises the series combination of R817, R818, R819, R820, and R821. As R is varied, the phase angle of the output signal is varied between zero and 180 degrees, while the amplitude remains fixed at E volts. During calibration of the phasemeter, R is adjusted to provide the 90-degree phase shift necessary to balance the phase detector bridge, while compensating for all fixed extraneous phase shifts introduced by the phasemeter circuitry.

1-47. Reference Amplifier Unit (See figure 1-11). The signal is fed from terminal B of J101 through C101 to the grid of V102. This tube acts as a phase splitter to drive the succeeding push pull stages. The signal is amplified in both halves of V103 and then applied to push-pull cathode follower V104. The cathodes of V104 are direct coupled to the grids of V105. Further amplification is provided by V105, whose plate load is the primary of transformer T101. Inverse feedback provided by resistors R119 and R120 insures phase and amplitude stability and provides freedom from the effects of individual tube and component variations.

1-48. The signal from the secondary of T101 forms one of the two inputs to the phase detector bridge. V101 is a matched quad of 1N144 semiconductor diodes, and forms part of the phase detector bridge.

1-49. Unknown Amplifier Unit (See figure 1-12). The Unknown Amplifier Unit amplifies the signal fed to the UNKNOWN input terminal of the phasemeter so that it may be applied to the phase detector bridge. The signal is taken from the arm of UNKNOWN LEVEL potentiometer R805 and applied through terminal A of J601 to the grid of the isolating cathode follower formed by the first half of V601. The signal then passes through a high-pass filter comprising R826 and either C807,



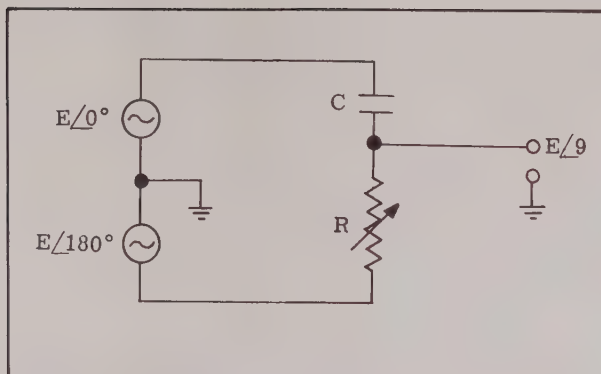


Figure 1-10. Uncalibrated Phase Shifter Basic Circuit

C808, or C809 plus R827, depending upon the frequency being used and the corresponding position of MULTIPLIER switch S804. The signal is then applied to the phase splitter consisting of the second half of V601. Push-pull amplification is provided by V602 and V603. The plate load of V603 is the primary of transformer T601. The signal from the secondary of T601 is the second input to the phase detector bridge. Inverse feedback is obtained through R617 and R618. A portion of the signal in this channel, taken from pin 8 of V601 is fed to the Sense Detector Unit via terminal M of J601.

1-50. Phase Detector Bridge. (See figure 1-13.) The bridge is an application of the ring modulator circuit. The d-c output current is a function of the input signal amplitudes and the cosine of the phase difference angle, and is zero when a 90-degree phase difference exists between the two inputs. The bridge input signals are obtained from transformer T101 in the Reference Amplifier Unit and transformer T601 in the Unknown Amplifier Unit. Voltmeter M804 monitors the level of the signal from the Reference Amplifier. This signal level is adjusted by means of REFERENCE LEVEL potentiometer R806. Voltmeter

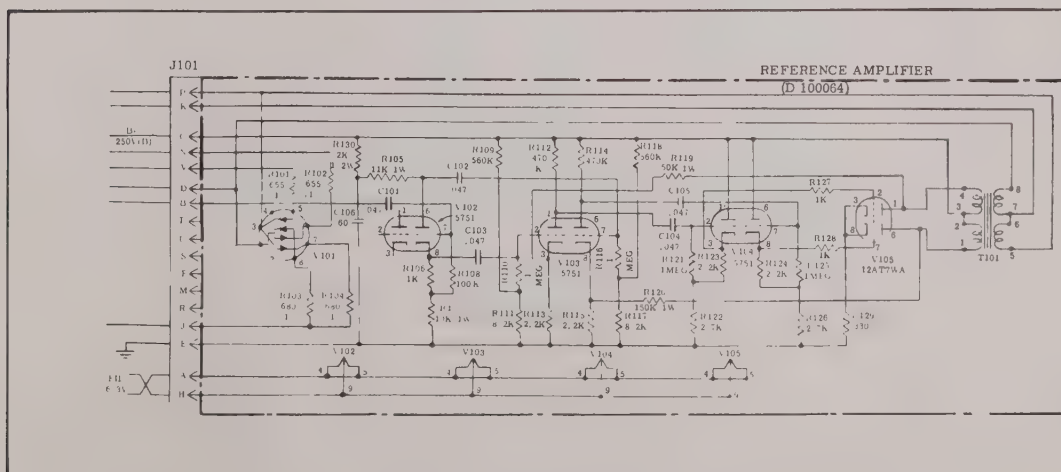
M803 monitors the level of the signal from the Unknown Amplifier, as set by UNKNOWN LEVEL potentiometer R805. Potentiometer R802 is adjusted to set the calibration of M803 so that the proper input signal amplitude is obtained for optimum bridge accuracy. Capacitor C816 provides high-frequency compensation for R802.

1-51. The diodes are a matched quad of type 1N144 units, mounted in sealed octal shell V101 located in the Reference Amplifier Unit. Resistors R101, R102, R103, and R104 are also located in this unit. DEGREES meter SET control R801 is used to adjust the d-c bridge balance when only one input signal is applied; thus, it compensates for differences among the individual diodes and resistors in the bridge circuit.

1-52. The d-c output current of the bridge is indicated by DEGREES microammeter M801. For a deviation from the balance condition of plus or minus one degree, the output is linear with angle to within 0.00005 degree. Therefore, the linear scale calibration of this meter is adequate for this interval. A deviation of  $\pm 10$  degrees is in error by 0.05 degree with a linear meter scale. This condition exists when meter switch S801 is set to X-10, shunting DEGREES meter M801 with R804 so that a  $\pm 10$ -degree meter range is obtained.

1-53. Capacitor C801 filters the d-c current in M801. The recorder jack permits substitution of the 600-ohm input circuit of a suitable recorder for DEGREES meter M801.

1-54. Sense switch S807 permits reversal of the polarity of the signal applied to the bridge from T601. This switch is set to the ADD  $180^\circ$  position when sense meter M802 indicates that 180 degrees must be added to the phase angle reading. This causes the bridge balance conditions to be in the same quadrature mode as existed during calibration. (Bridge balance can occur with the reference signal either leading or lagging the unknown signal.)



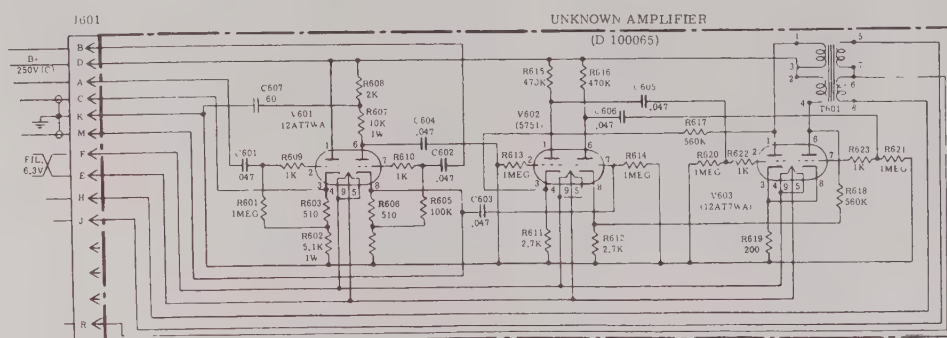
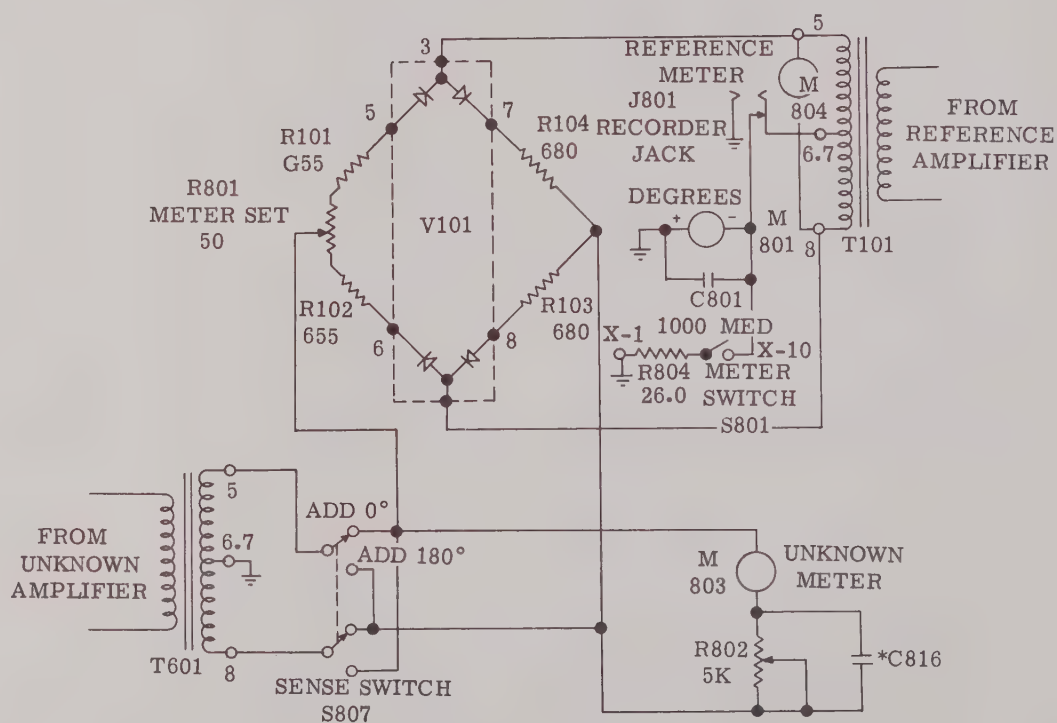


Figure 1-12. Unknown Amplifier Schematic



\* VALUE SELECTED AT CALIBRATION  
(APPROX. 3700 UUF).

Figure 1-13. Phase Detector Bridge Schematic

T702. One input to this bridge is approximately 90 degrees out of phase with one input to the phase detector bridge, while the other input to this bridge is in phase with the second input to the phase detector bridge. The phase detector bridge balances when its inputs are 90 degrees out of phase with each other. Thus, when the phase detector bridge is balanced, the two inputs to the sense detector bridge are either in phase or 180 degrees out of phase with each other. The d-c output current of the Sense Detector is therefore near its maximum value, and is of either one polarity or the other.

1-57. Power Supply. (See figure 1-16). The power supply provides 6.3 volts ac (grounded center tap) to the filaments and +250 volts dc for all other circuits. The d-c output voltage is controlled by a 5000-ohm potentiometer, R921, which is adjusted and locked at the factory. High voltages from terminals 3-5 and 607 of power transformer T901, with their associated rectifiers (1N1764 silicon diodes) and their related filter circuits, provide the d-c voltages to the regulator amplifiers and control tubes of the power supply. The regulating system operates so that the output voltage is substantially independent of the load. Pass tubes V902, V903, and V904 are in series with the load, and the d-c output is taken from their cathodes. Voltage regulator V905 sets the cathode of tube V907 and the plate voltage of tube V9-8. The stable 5651, V906 voltage reference tube supplies the grid (pin 2) of tube V908 with a constant reference voltage that is independent of the current through V908. Any deviation from the normal operating d-c output voltage will be influenced by the amplifiers, which will ultimately be felt at the grids of the pass tubes. The current in the pass tubes will thereby change, so that the original change in the output is cancelled out. The +250 volts regulated output is supplied via terminals A, B, and C of TB901 to the seven individual chassis of the phasemeter section.

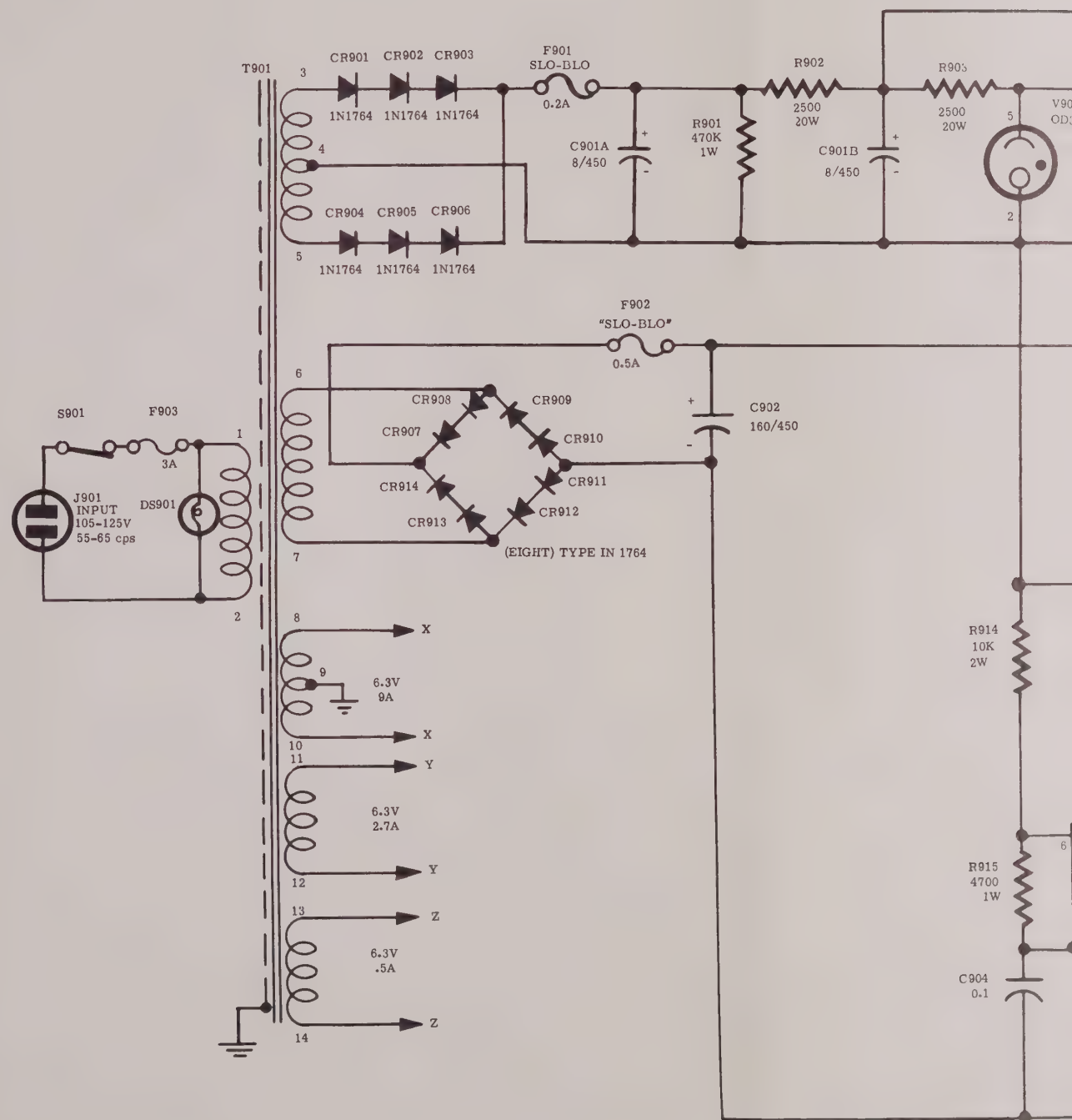
1-59. Figure 1-15 lists the leading particulars for the Model 901/1010 Phasemeter.



1-11

|                                  |                                     |
|----------------------------------|-------------------------------------|
| Frequency Range .....            | 30 cps to 20,000 cps                |
| Phase Range .....                | 0 to 360 degrees                    |
| Accuracy .....                   | 0.1 degree absolute                 |
|                                  | 0.01 degree incremental             |
| Input Signal Level.....          | 0.5 to 10 volts rms                 |
| Allowable Harmonic Content ..... | 1% maximum total harmonic content   |
|                                  | 0.5% maximum third harmonic         |
| Input Impedance .....            | 15 megohms shunted by 25 uuf        |
| Power Supply Requirements .....  | 105 to 125 volts rms, 2 amp, 60 cps |
| Dimensions.....                  | 20 inches wide                      |
|                                  | 15-1/2 inches deep                  |
|                                  | 15-1/2 inches high                  |
| Weight .....                     | 97 pounds                           |

Figure 1-15. Leading Particulars.



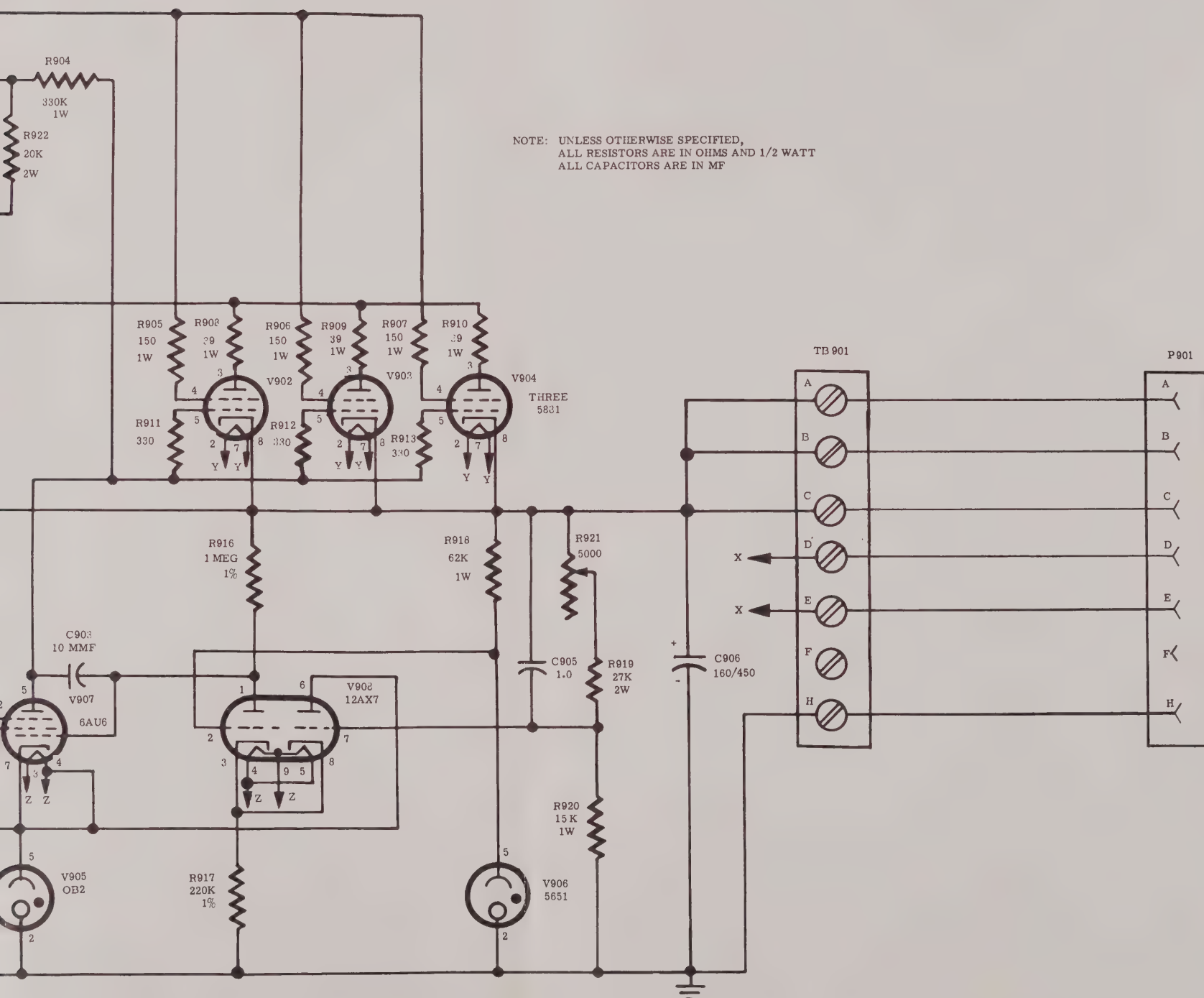


Figure 1-16. Power Supply Schematic

## SECTION II

## TEST EQUIPMENT AND SPECIAL TOOLS

## 2-1. TEST EQUIPMENT.

2-2. The only test equipment required to perform maintenance on the phasemeter is a single signal source and two uncalibrated variable phase shifters. The input and output impedance of the phase shifter must be sufficiently high and low so that loading one output with the other input introduces less than 0.01-degree phase change. The output impedance must

also be sufficiently low so that less than 0.01-degree change results when the Phasemeter input circuit is used as a load for either phase shifter.

## 2-3. SPECIAL TOOLS.

2-4. There are no special tools required to overhaul the Model 901/1010 Phasemeter.

## SECTION III

## MAINTENANCE BEYOND CAPABILITIES OF FIELD

## 3-1. GENERAL.

3-2. This section provides information essential for determining the extent of overhaul required and the usability of component parts.

## 3-3. UNIT TEST.

3-4. Perform the tests as outlined in section XI. Analyze any poor performance in accordance with figure 3-1.

| Trouble Indication                                                                                    | Analysis                                                                                                                    |
|-------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|
| 1. Pilot lamp does not light when power switch is turned on.                                          | Check line plug in 115-volt, 60-cycle source. Check that line cord is connected at rear of phasemeter cabinet. Check fuses. |
| 2. DEGREES meter pointer does not deflect.                                                            | Check diode assembly V101. Check capacitor C801 for short.                                                                  |
| 3. DEGREES meter does not balance after preliminary adjustments have been made.                       | Check diode assembly V101. Check resistors R101, R102, R103, R104, and potentiometer R801.                                  |
| 4. DEGREES meter does not balance with proper levels indicated by REFERENCE and UNKNOWN LEVEL meters. | Check DEGREES COARSE, MEDIUM, and FINE controls R817, R819, R821, and capacitors C810, C811, and C812.                      |
| 5. DEGREES meter tries to follow a-c signal.                                                          | Check capacitor C801 for open.                                                                                              |

Figure 3-1. Analyzing Trouble (Sheet 1 of 2)

| Trouble Indication                                                                                                               | Analysis                                                                                                                                                                                                                                                                                                           |
|----------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 6. BALANCE meter pointer does not deflect.                                                                                       | Check capacitor C803 for short. Check tubes V203, V206, and V207. Check voltages on these tubes.                                                                                                                                                                                                                   |
| 7. BALANCE meter follows a-c signal.                                                                                             | Check capacitor C803 for open.                                                                                                                                                                                                                                                                                     |
| 8. BALANCE meter does not balance with zero signal when BALANCE COMPARE switch is set at ZERO position.                          | Check tubes V203, V206, and V207. Check voltages on these tubes.                                                                                                                                                                                                                                                   |
| 9. BALANCE meter does not balance with proper signal level in the reference channel and with BALANCE COMPARE switch set to ZERO. | Check all tubes in VTVM unit. Check voltages on these tubes. Check BALANCE switch S803. Check for voltages at this switch.                                                                                                                                                                                         |
| 10. BALANCE meter does not balance with BALANCE COMPARE switch set at COMPARE.                                                   | Check tubes V502, V503, V504, and V505. Check switches S802 and S803. Check BALANCE COARSE MEDIUM, and FINE controls. Check capacitors C813, C814, and C815. Check voltages in 90-Degree Amplifier Unit. Check 90-Degree Amplifier for high-frequency oscillation. Check resistors in potentiometer assembly Z801. |
| 11. REFERENCE level meter does not read at red line with 0.5-volt a-c input signal.                                              | Check that switch S802 is in CALIBRATE position. Check all tubes in Adder and Phase-Shifter Unit, as well as in Reference Amplifier. Check voltages on these tubes. Check transformer T101. Check for short at phasemeter input terminals.                                                                         |
| 12. REFERENCE level meter reads with no input signal.                                                                            | Check coupling capacitors and grid resistors associated with tubes in Adder and Phase-Shifter Unit and Reference Amplifier.                                                                                                                                                                                        |
| 13. Phase error at 44° - 46°.                                                                                                    | Balance gm of V301, V302 and V303, V304 (5751 tubes) in adder unit to within 5%. See calibration procedure.                                                                                                                                                                                                        |

Figure 3-1. Analyzing Trouble

## SECTION IV

## DISMANTLING AND DISASSEMBLY

## 4-1. DISMANTLING.

4-2. The precision phasemeter should be dismantled in accordance with the following instructions and in conjunction with the exploded view.

## NOTE

Disconnect electrical leads as necessary before removing components.

a. Remove phasemeter assembly (1, figure 4-1) from case (3) and disassemble in accordance with paragraph 4-3.

b. Remove power supply (2) from case (3) and disassemble in accordance with paragraph 4-14.

## 4-3. DISASSEMBLY.

4-4. PHASE METER ASSEMBLY. To disassemble the phasemeter assembly proceed as follows:

a. Remove input follower (1, figure 4-2) by removing attaching hardware and disassemble in accordance with paragraph 4-5.

b. Remove 90-degree amplifier (2) by removing attaching hardware and disassemble in accordance with paragraph 4-6.

c. Remove VTVM unit (3) by removing attaching hardware and disassemble in accordance with paragraph 4-7.

d. Remove adder and phase shifter (4) by removing attaching hardware and disassemble in accordance with paragraph 4-8.

e. Remove reference amplifier (5) by removing attaching hardware and disassemble in accordance with paragraph 4-9.

f. Remove unknown amplifier (6) by removing attaching hardware and disassemble in accordance with paragraph 4-10.

g. Remove sense detector (7) by removing attaching hardware and disassemble in accordance with paragraph 4-11.

h. Remove multiplier switch (8) by removing attaching hardware and disassemble in accordance with paragraph 4-12.

i. Remove front panel assembly (9) and disassemble in accordance with paragraph 4-13.

## 4-5. INPUT FOLLOWER.

a. Remove tube shield (1, figure 4-3) from electron tube (2), remove tube (2).

b. Remove cover (3) by removing screw (4) and washer (5).

c. Remove tube socket (6) by removing screw (7) washer (8), standoff (9) and terminal (10).

d. Remove connector (11) by removing screw (12) washer (13) and standoff (14).

e. Remove capacitors (15) and resistors (16).

f. Remove grommets (17) from base (18).

## 4-6. 90-DEGREE AMPLIFIER.

a. Remove electron tube shields (1, figure 4-4) and tubes (2 and 3).

b. Remove capacitors (4), resistors (5) and lamp (6) by unsoldering leads.

c. Remove capacitor (7) by removing screw (8), washer (9) and nut (10).

d. Remove tube socket (11) by removing screw (12), washer (13) and nut (14).

e. Remove connector (15) by removing screw (16), washer (17) and nut (18).

f. Remove standoff (19) by removing washer (20), and screw (21).

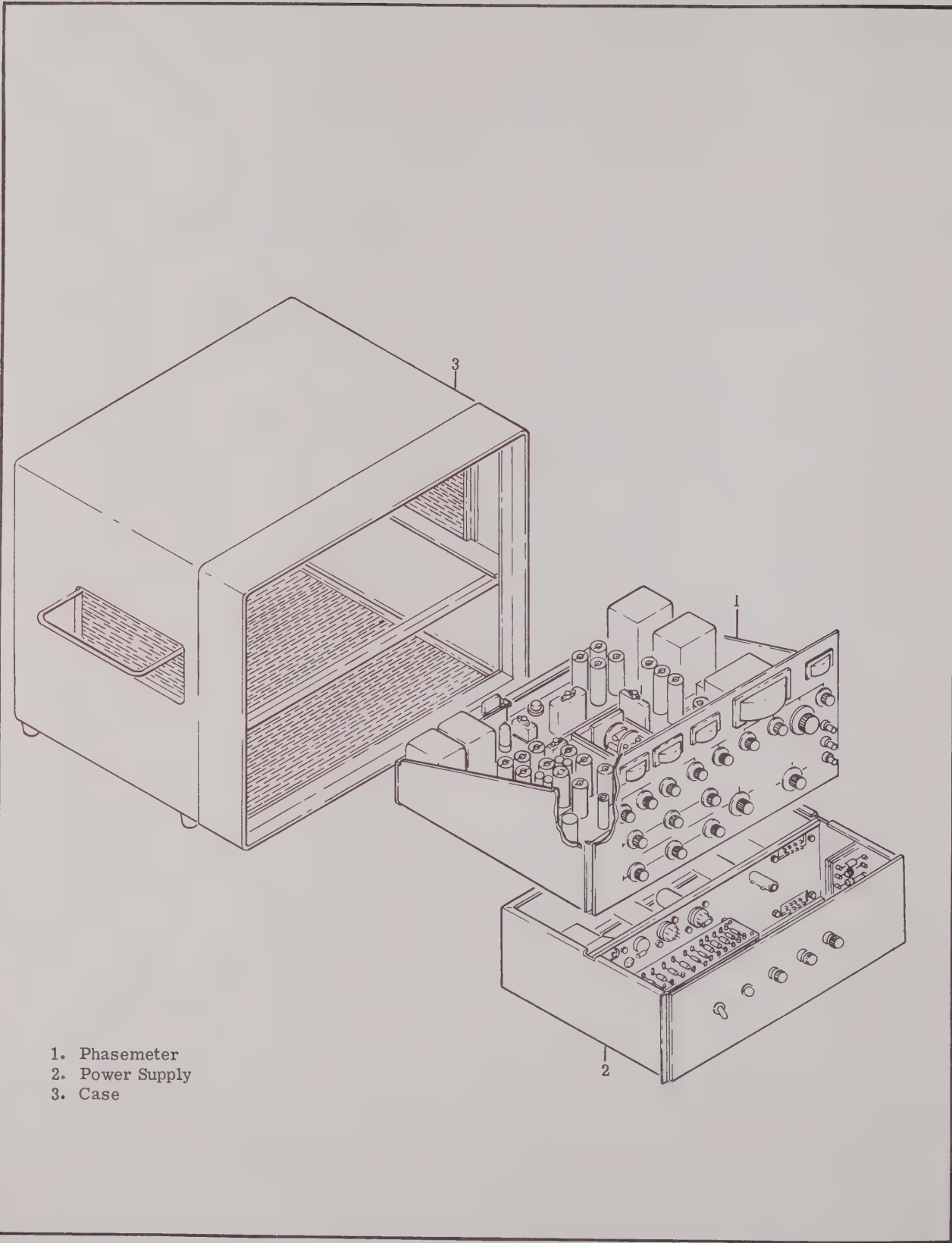
g. Remove clock (22) from base (28).

h. Remove terminal (23) by unsoldering ends from standoff (24).

i. Remove standoff (24) by removing spacer (25), screw (26) and washer (27).

## 4-7. VTVM UNIT.

a. Remove electron tube shield (1, figure 4-5) and electron tube (2).



- 1. Phasemeter
- 2. Power Supply
- 3. Case

Figure 4-1. Model 901/1010 Phasemeter

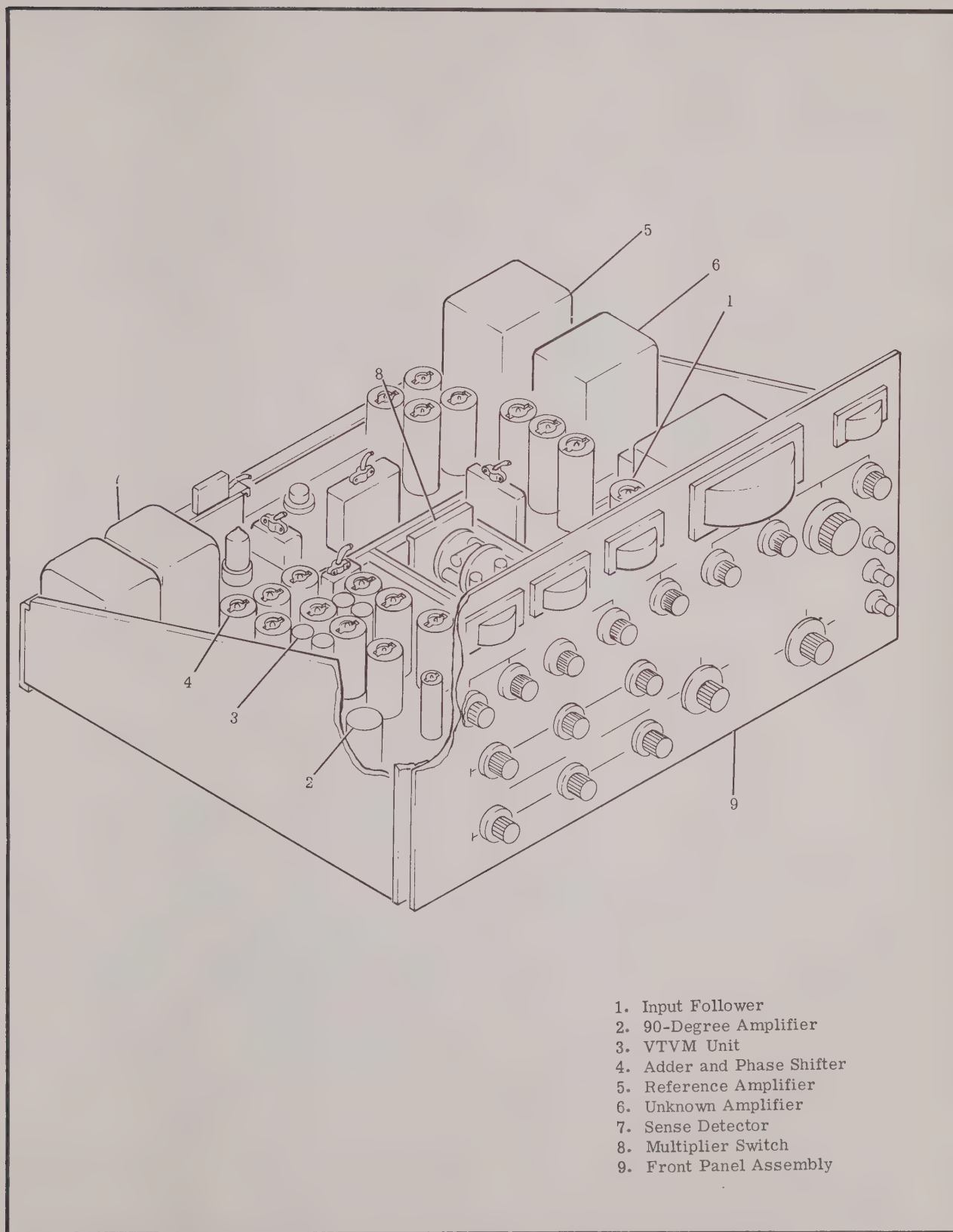


Figure 4-2. Phasemeter Assembly

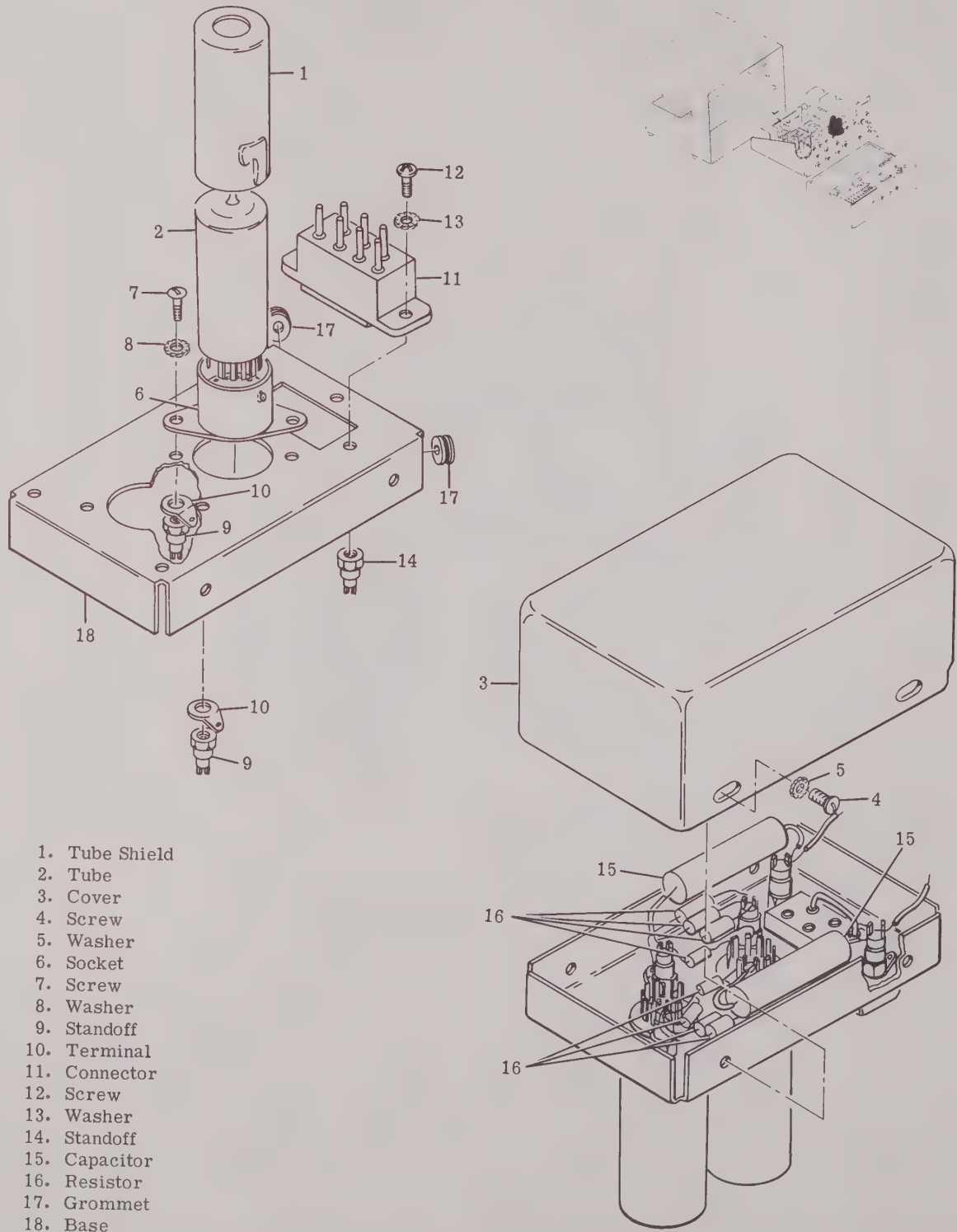


Figure 4-3. Input Follower

b. Remove capacitor (3) and resistor (4) by unsoldering leads.

c. Remove capacitor (5) by removing attaching nut.

d. Remove electron tube socket (6) by removing screw (7), washer (8), nut (9) and standoff (10).

e. Remove connector (11) by removing screw (12), terminal (13), washer (14) and nut (15).

#### 4-8. ADDER AND PHASE SHIFTER.

a. Remove electron tube shield (1, figure 4-6) and electron tube (2).

b. Remove capacitor (3) and resistor (4) by unsoldering leads.

c. Remove electron tube socket (5) by removing screw (6), washer (7) and nut (8).

d. Remove connector (9) by removing screw (10), terminal (11), washer (12) and nut (13).

e. Remove standoff (14), washer (15), screw (16) and spacer (17) from base (24).

f. Remove resistor (18) by removing screw (19), spacer (20), washers (21 and 22) and nut (23).

#### 4-9. REFERENCE AMPLIFIER.

a. Remove electron tube shield (1, figure 4-7) and electron tube (2).

b. Remove transformer (3) by removing screw (4), washer (5) and nut (6).

c. Remove Quad Diode (7) from socket (18).

d. Remove resistors (8) and capacitors (9) by unsoldering leads.

e. Remove connector (10) by removing screw (11), washer (12) and nut (13).

f. Remove tube socket (14) by removing screw (15), washer (16) and nut (17).

g. Remove diode socket (18) by removing screw (19), washer (20) and nut (21).

h. Remove spacer (22), standoff (23), washer (24) and screw (25).

i. Remove standoff (26) by removing washer (27) and screw (28).

#### 4-10. UNKNOWN AMPLIFIER.

a. Remove electron tube shield (1, figure 4-8) and electron tubes (2 and 3).

b. Remove connector (4) by removing screw (5), washer (6) and nut (7).

c. Remove transformer (8) by removing screw (9), washer (10) and nut (11).

d. Remove capacitors (12) and resistors (13) by soldering leads.

e. Remove standoffs (14), spacer (15), washer (16 and 18) and screw (17 and 19).

f. Remove capacitor (20) by removing screw (21), washer (22) and nut (23).

g. Remove tube sockets (24) by removing screw (25), washer (26) and nut (27).

#### 4-11. SENSE DETECTOR UNIT.

a. Remove electron tube shield (1, figure 4-9) and electron tube (2).

b. Remove capacitor (3) by removing screw (4), and washer (5).

c. Remove rectifier (6) by removing screw (7), washer (8) and nut (9).

d. Remove resistors (10) by unsoldering leads.

e. Remove transformer (11) by removing screw (12) and washer (13).

f. Remove electron tube socket (14) by removing screw (15), washer (16) and nut (17).

g. Remove connector (18) by removing screw (19), washer (20) and nut (21).

#### 4-12. MULTIPLIER SWITCH.

a. Remove bracket (1, figure 4-10) by removing nut (2).

b. Remove capacitor board (3) by removing nut (4).

c. Remove capacitors (5) from board (3) by unsoldering leads.

d. Remove washer (6) from switch (7).

#### 4-13. FRONT PANEL ASSEMBLY.

a. Remove meter sense indicator (1, figure 4-11) by removing screw (2).

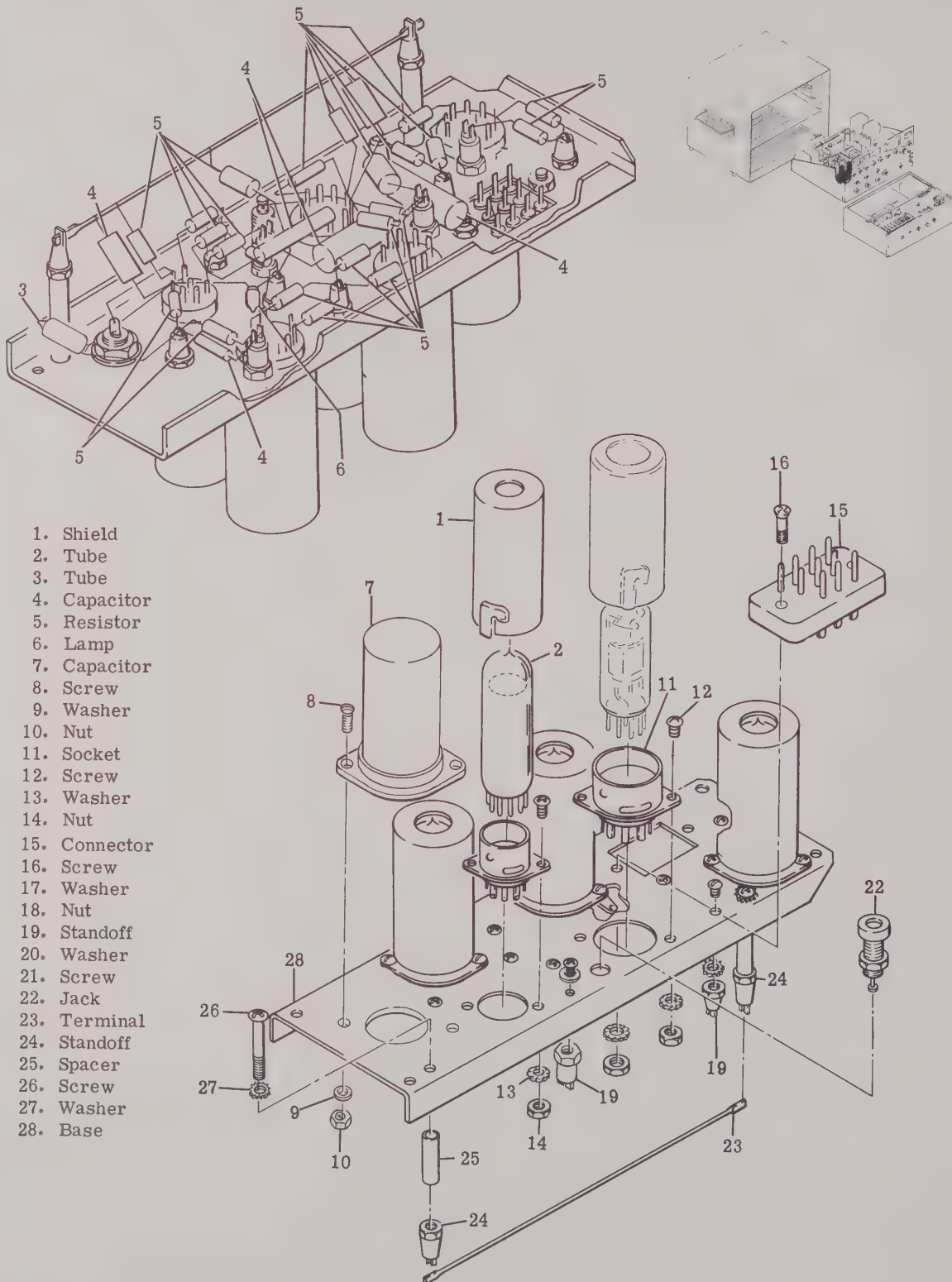


Figure 4-4. 90-Degree Amplifier

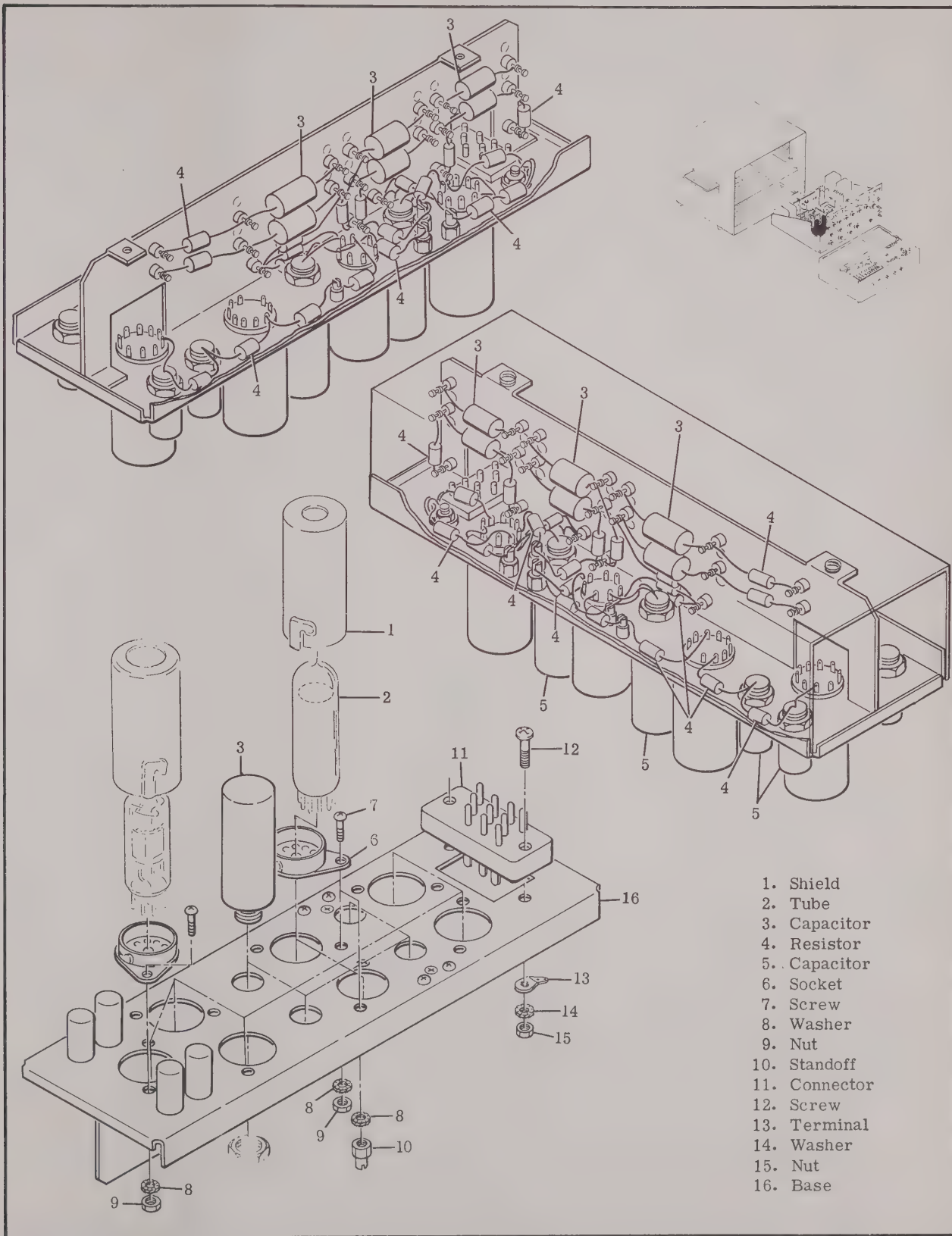
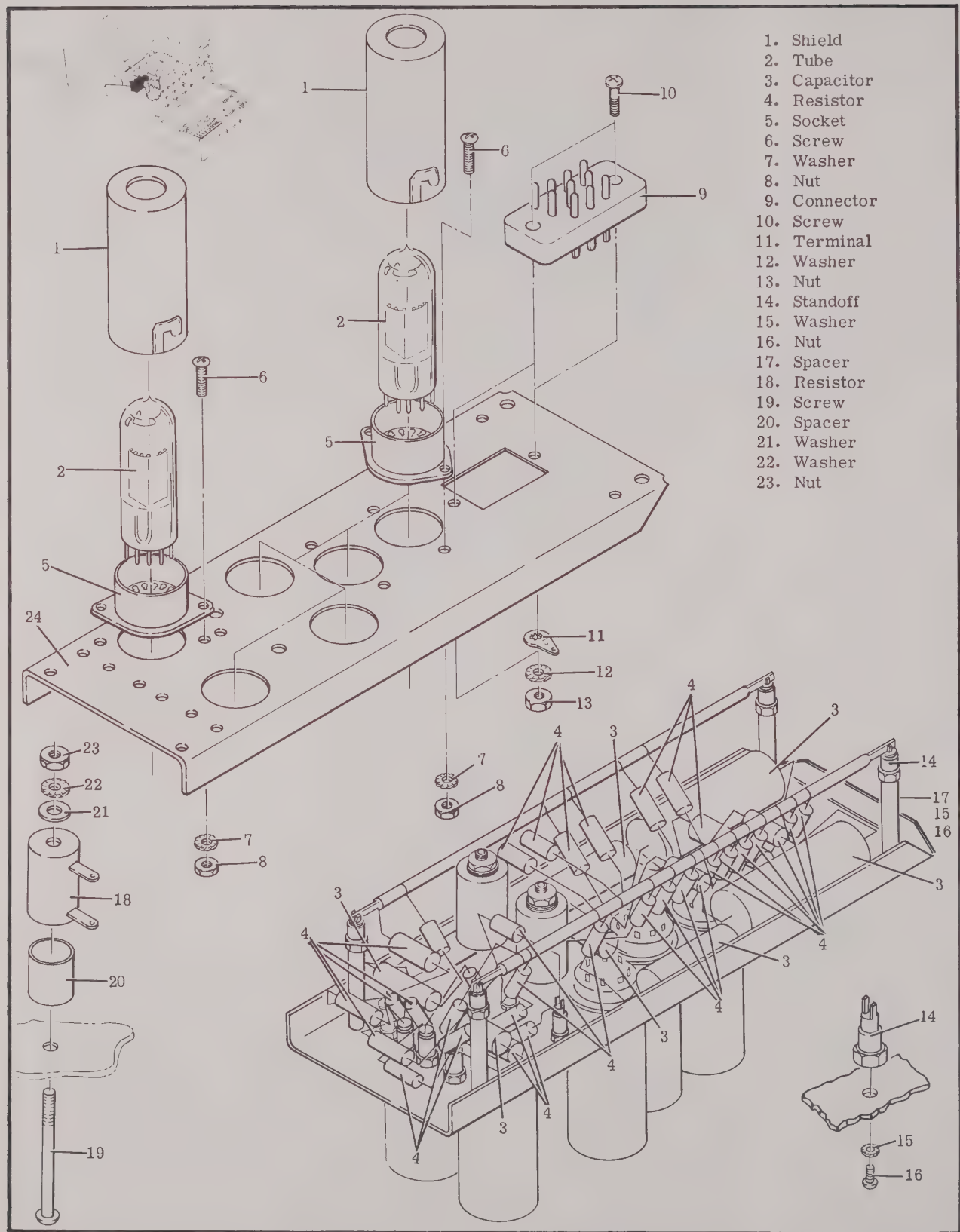


Figure 4-5. VTVM



1. Shield
2. Tube
3. Capacitor
4. Resistor
5. Socket
6. Screw
7. Washer
8. Nut
9. Connector
10. Screw
11. Terminal
12. Washer
13. Nut
14. Standoff
15. Washer
16. Nut
17. Spacer
18. Resistor
19. Screw
20. Spacer
21. Washer
22. Washer
23. Nut

Figure 4-6. Adder and Phase Shifter

b. Remove degrees meter (3) by removing screw (4), washer (5) and nut (6).

c. Remove capacitor (7) from rear of meter (3).

d. Remove X-1-X-10 switch (8), resistor (9) and  $+0^\circ - + 180^\circ$  switch from front panel (75).

e. Remove potentiometer (11) by removing nut (12).

f. Remove bracket (13) by removing screw (14) and nut (15).

g. Remove unknown meter (16) by removing screw (17).

h. Remove reference meter (18) by removing screw (20).

i. Remove balance meter (19) by removing screw (20).

j. Remove resistor (21) and capacitor (22) by unsoldering leads.

k. Remove standoff (23) by removing screw (24), and washer (25).

l. Remove unknown level switch (26) reference level switch ( $\pm$ ) and zero-compare switch (28) from front panel (75).

m. Remove balance set potentiometer (29) and zero potentiometer (30) from front panel.

n. Remove balance meter null potentiometers (31, 32 and 33) from panel.

o. Remove degrees meter null potentiometers (34, 35 and 36) from panel.

p. Remove CPS switch (37) and set switch (38) from panel.

q. Remove jack (39) by removing insulating spacer (40), washer (41) and nut (42).

r. Remove phase switch (43) and degrees control (44).

s. Remove recorder jack (45) by removing nut (46).

t. Remove bracket (47) by removing screw (48), washer (49), and nut (50).

u. Remove bracket (51) by removing screw (52), washer (53) and nut (54).

v. Remove bracket (55) by removing screw (56) and washer (57).

w. Remove brace (58) by removing screw (59), and washer (60).

x. Remove brace (61) by removing screw (62) and washer (63).

y. Remove brace (64).

z. Remove back plate (65) by removing screw (66) washer (67) and nut (68).

aa. Remove left side (69) and right side (70) by removing screw (71), spacer (72), washer (73) and nut (74).

#### 4-14. POWER SUPPLY.

4-15. To disassemble the power supply, use the following steps in conjunction with figure 4-12.

a. Remove front panel (1) by removing screw (2) and nut (3).

b. Remove bracket (4).

c. Remove bracket (5) by removing screw (6), washer (7) and nut (8).

d. Remove switch (9), light (10), fuse holder (11) and fuses (12, 13 and 14) from front panel (1).

e. Remove diode boards (15 and 21) by removing screw (16), washer (17) and nut (18).

f. Remove diodes (19) and resistor (20) from boards (15 and 21).

g. Remove brackets (22) by removing screws (23) and washer (24).

h. Remove bracket assembly (25) by removing screws (26) and washer (27).

i. Remove resistor board (28) by removing screw (29) and washer (30).

j. Remove capacitors (31 and resistors (32) from board (28).

k. Remove bracket (33) by removing screws (34) and washer (35).

l. Remove resistor (36) by removing screw (37) nut (38) and washer (39).

m. Remove resistor (40) by unsoldering leads.

n. Remove transformer (41) by removing nut (42).

o. Remove capacitor (44) and electron tubes (45).

p. Remove shield (46) and electron tube (47).

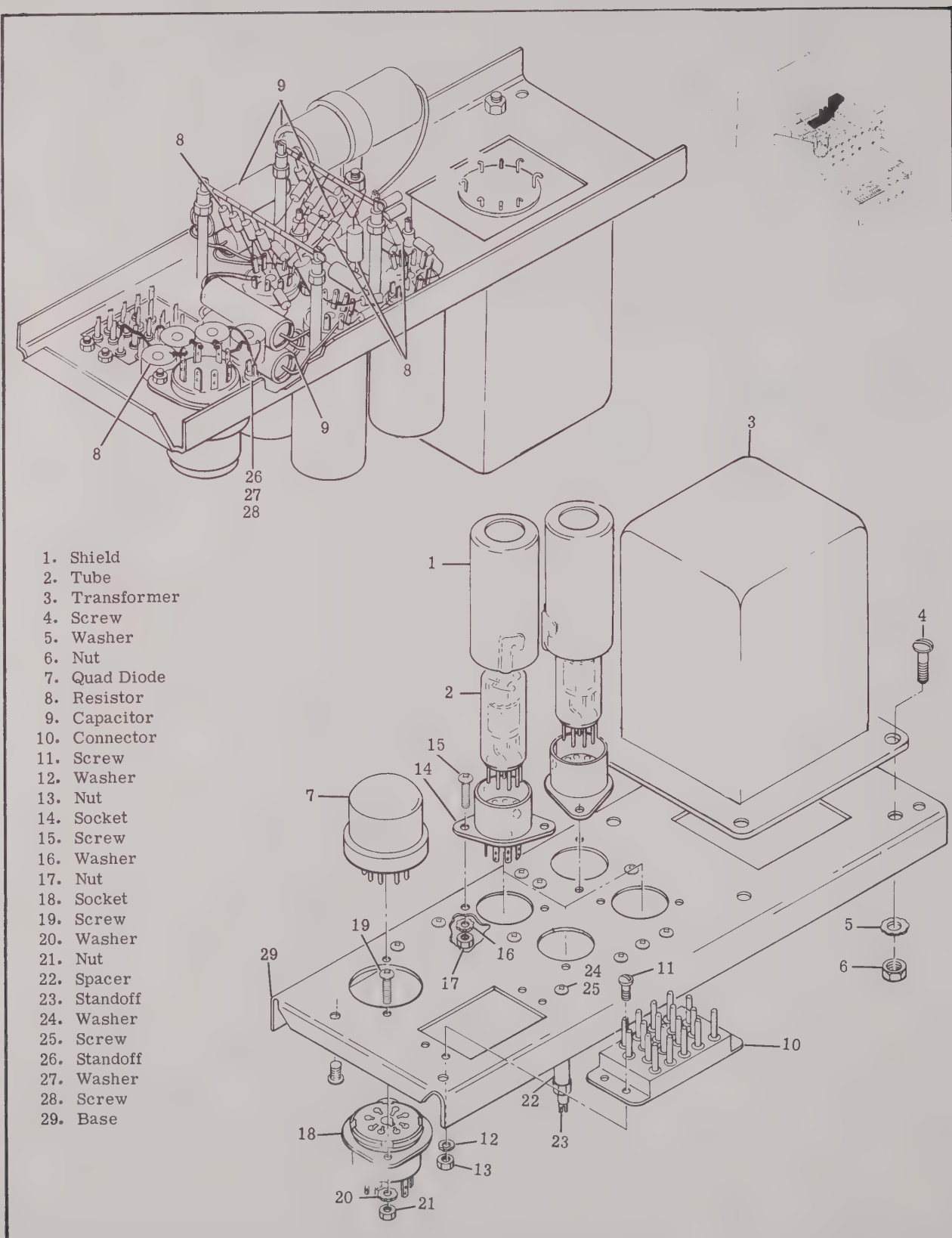


Figure 4-7. Reference Amplifier

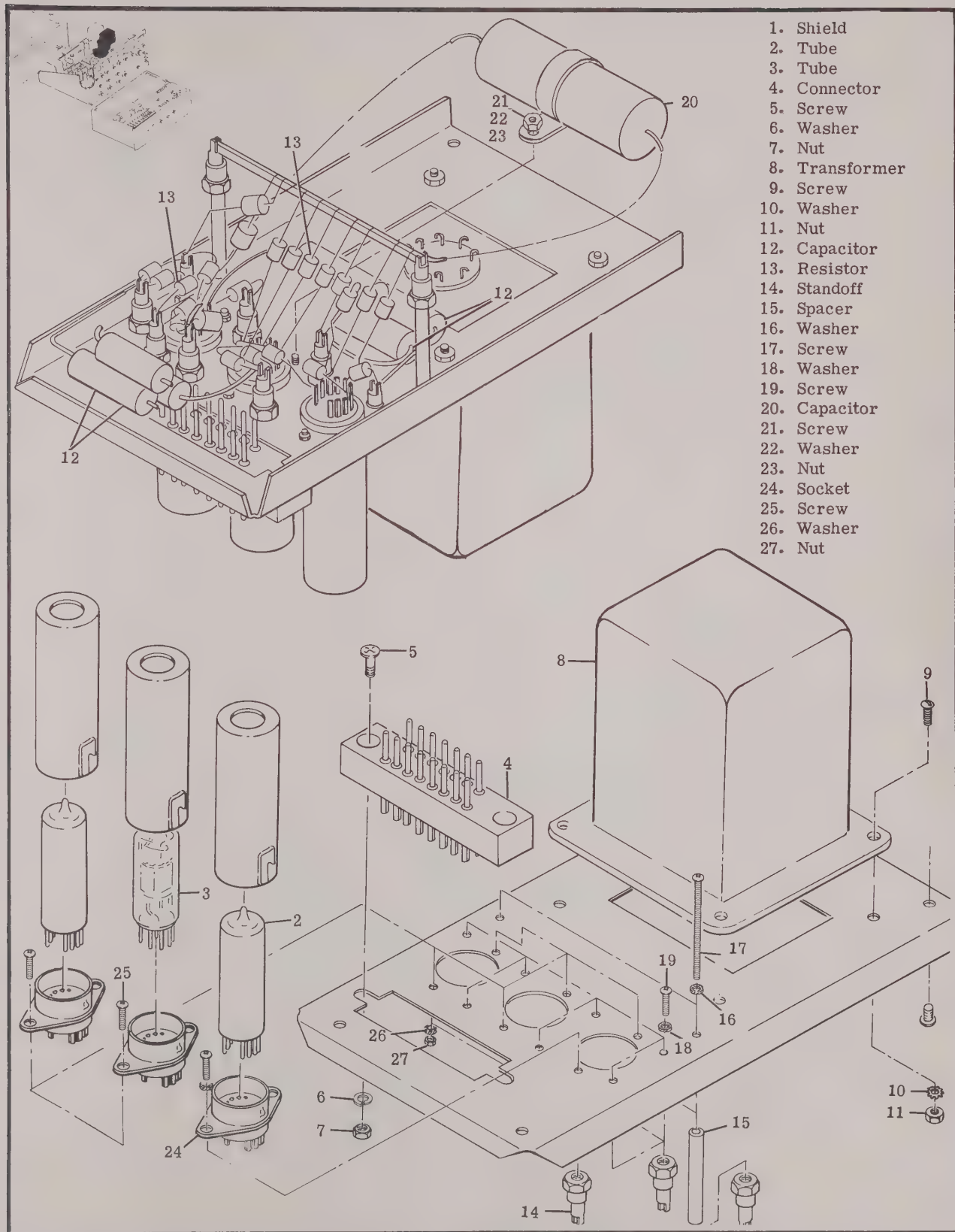


Figure 4-8. Unknown Amplifier

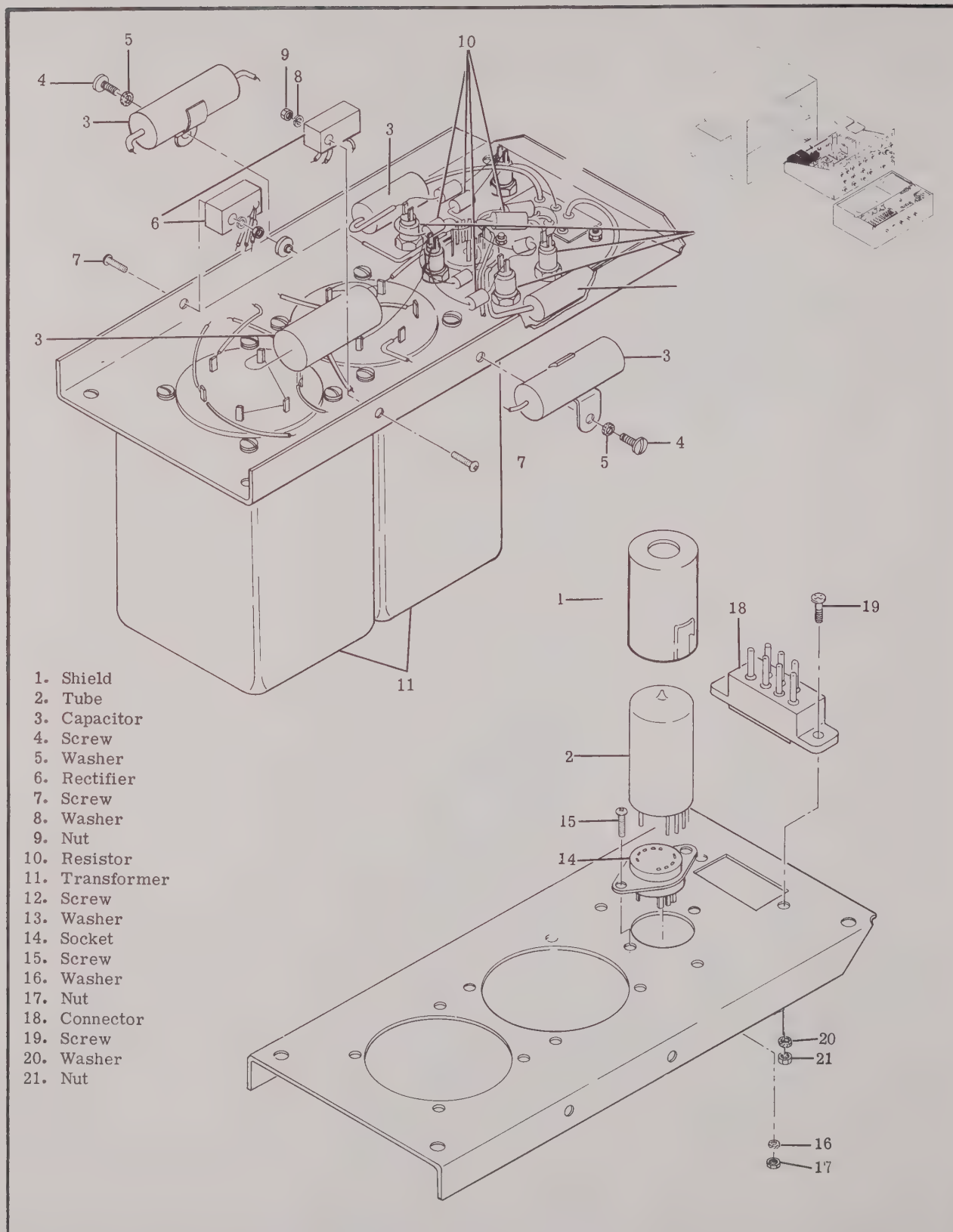


Figure 4-9. Sense Detector Unit

q. Remove tube socket (48 and 53) by removing screw (49 and 54), washer (50 and 55) and nut (51 and 56).

r. Remove potentiometer (52).

s. Remove capacitor (57) by removing screw (58), washer (59) and nut (60).

t. Remove connector (61) by removing screw (62) and nut (63).

u. Remove bracket (64) by removing screw (65), washer (66) and nut (67).

v. Remove clamp (68) by removing screw (69), washer (70) and nut (71).

w. Remove terminal board (72) by removing screw (73), washer (74) and nut (75).

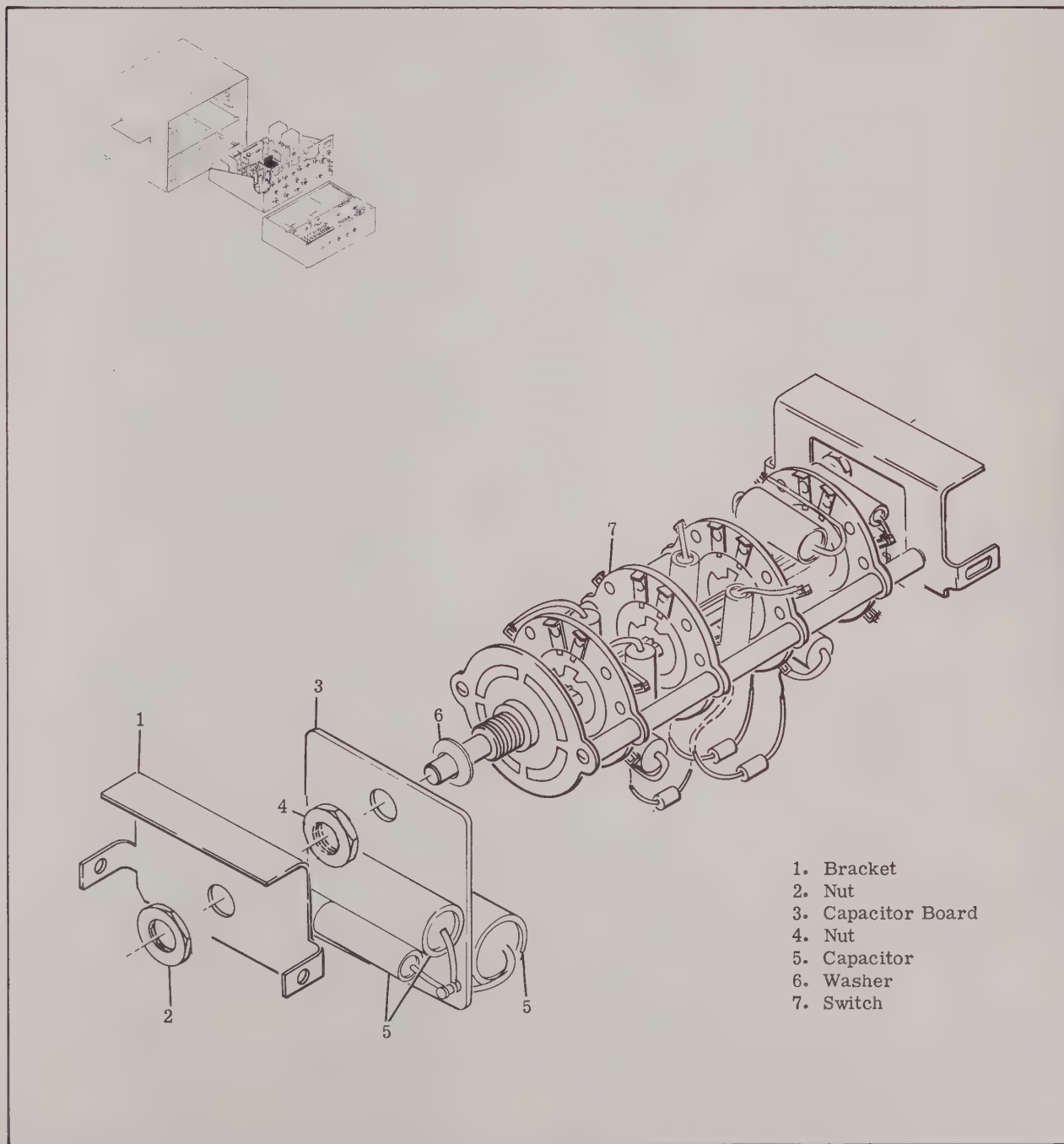


Figure 4-10. Multiplier Switch

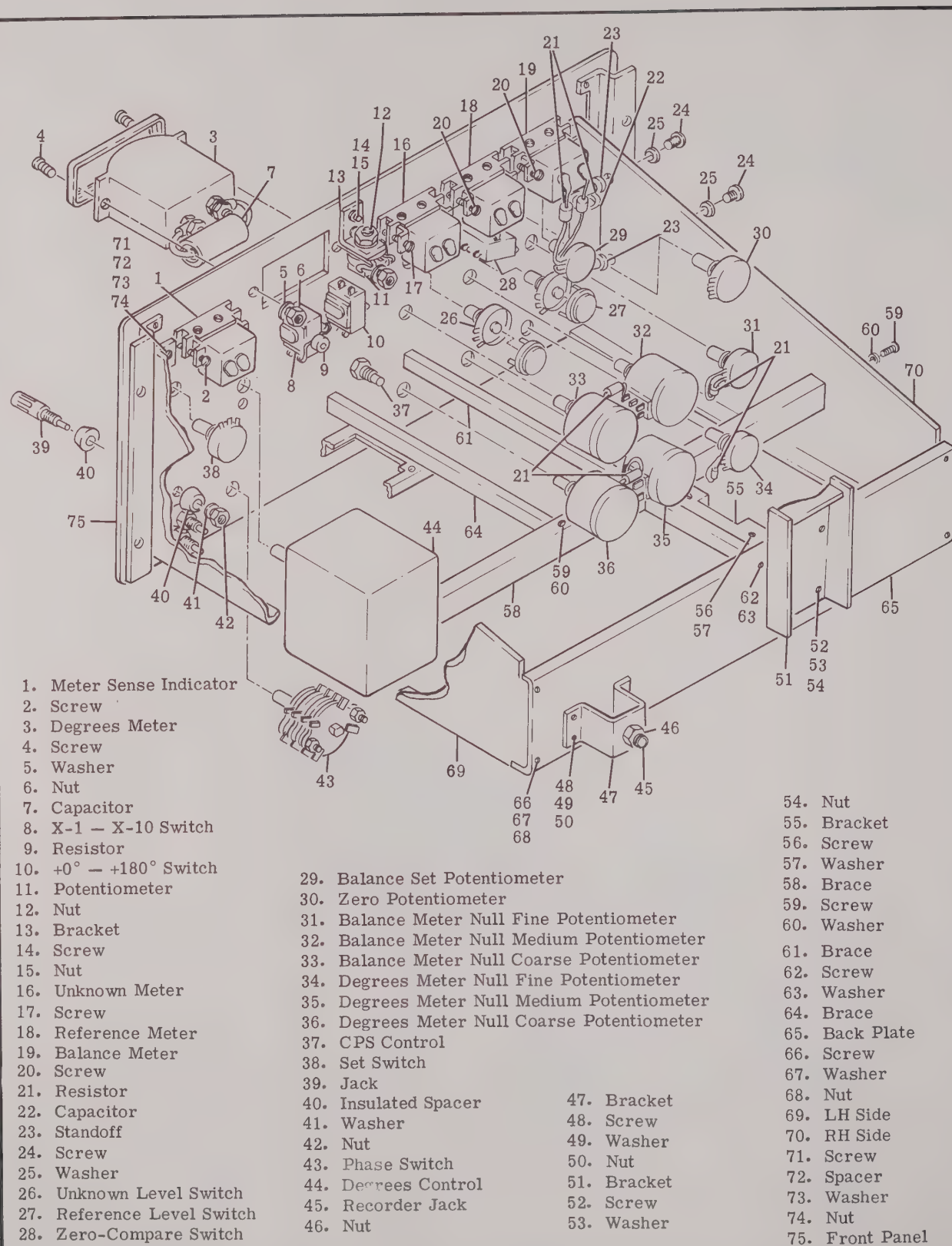
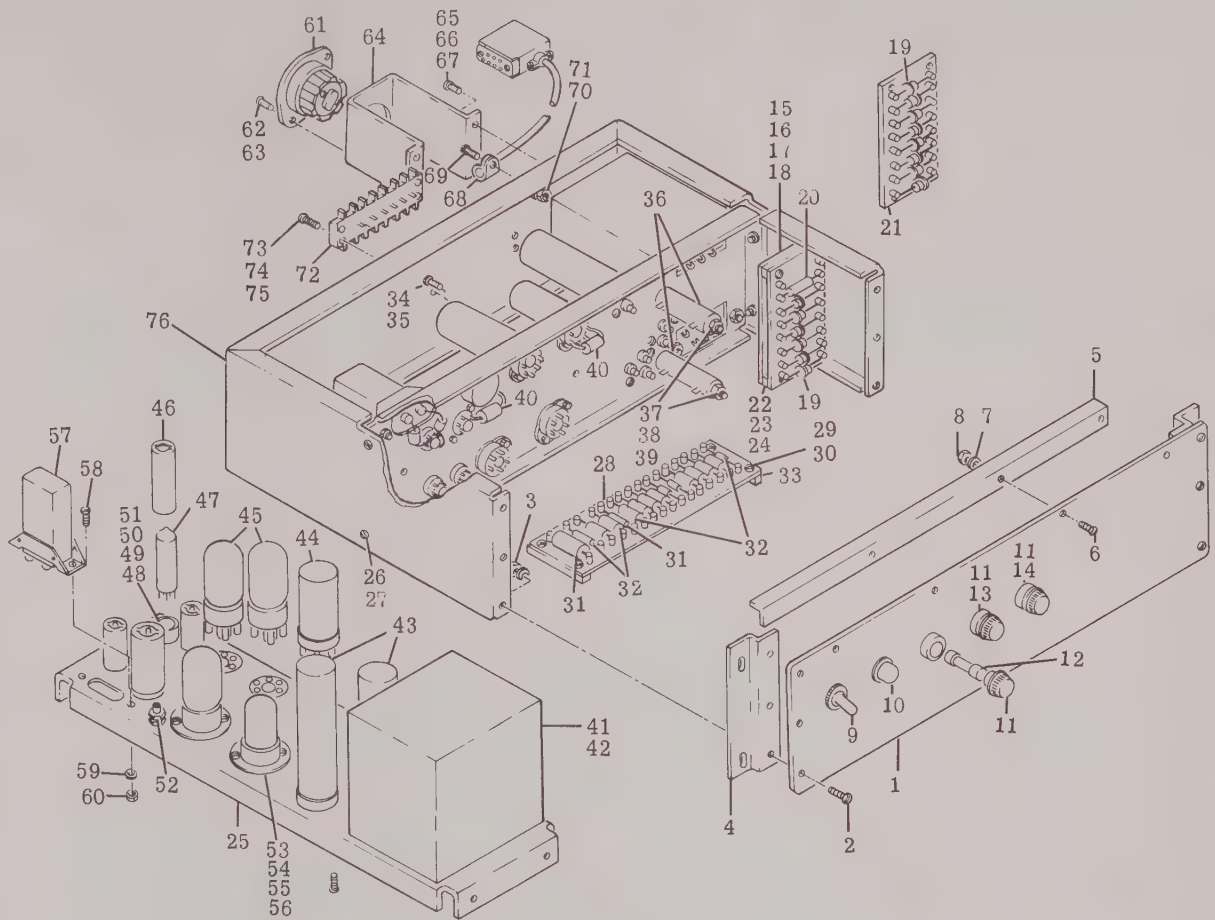


Figure 4-11. Front Panel Assembly



- |                       |                      |                   |                    |
|-----------------------|----------------------|-------------------|--------------------|
| 1. Front Panel        | 23. Screw            | 45. Electron Tube | 67. Nut            |
| 2. Screw              | 24. Washer           | 46. Shield        | 68. Clamp          |
| 3. Nut                | 25. Bracket Assembly | 47. Electron Tube | 69. Screw          |
| 4. Bracket            | 26. Screw            | 48. Socket        | 70. Washer         |
| 5. Bracket            | 27. Washer           | 49. Screw         | 71. Nut            |
| 6. Screw              | 28. Resistor Board   | 50. Washer        | 72. Terminal Board |
| 7. Washer             | 29. Screw            | 51. Nut           | 73. Screw          |
| 8. Nut                | 30. Washer           | 52. Potentiometer | 74. Washer         |
| 9. Switch             | 31. Capacitor        | 53. Socket        | 75. Nut            |
| 10. Light             | 32. Resistor         | 54. Screw         | 76. Frame          |
| 11. Fuse Holder       | 33. Bracket          | 55. Washer        |                    |
| 12. 3 Amp Fuse        | 34. Screw            | 56. Nut           |                    |
| 13. 1/2 Amp Fuse      | 35. Washer           | 57. Capacitor     |                    |
| 14. 2 Amp Fuse        | 36. Resistor         | 58. Screw         |                    |
| 15. Front Diode Board | 37. Screw            | 59. Washer        |                    |
| 16. Screw             | 38. Nut              | 60. Nut           |                    |
| 17. Washer            | 39. Washer           | 61. Connector     |                    |
| 18. Nut               | 40. Resistor         | 62. Screw         |                    |
| 19. Diode             | 41. Transformer      | 63. Nut           |                    |
| 20. Resistor          | 42. Nut              | 64. Bracket       |                    |
| 21. Rear Diode Board  | 43. Capacitor        | 65. Screw         |                    |
| 22. Bracket           | 44. Capacitor        | 66. Washer        |                    |

Figure 4-12. Power Supply

## SECTION V

## CLEANING.

## 5-1. GENERAL.

## CAUTION

5-2. Cleaning of the component parts of the phase-meter should be confined to the procedures outlined in figure 5-1.

Avoid soaking any of the electrical components in cleaning solvent.

| COMPONENT                                  | CLEANING PROCEDURE                                                                                                                                          |
|--------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Terminal and lugs                          | Clean all terminals with a cloth dampened in cleaning solvent, Federal Specification P-S-661.                                                               |
| Switches, potentiometers, and tube sockets | Clean with compressed air and a soft bristled brush. Remove any excess dirt with a cloth.                                                                   |
| Case and frame                             | Clean these parts by wiping with a cloth dampened with solvent, Federal Specification P-S-661. Wipe dry with a clean lint-free cloth or use compressed air. |

Figure 5-1. Cleaning

SECTION VI  
INSPECTION

## 6-1. GENERAL.

6-2. Carefully inspect all parts for damage. Replace damaged wiring in accordance with schematic diagram

figure 1-4. Check terminal connections. Refer to figure 6-1 for inspection procedures.

| NOMENCLATURE   | PROCEDURE                                                                                    |
|----------------|----------------------------------------------------------------------------------------------|
| Capacitors     | Check for shorted or grounded capacitors.                                                    |
| Resistors      | Visually inspect for burned or cracked resistors. Inspect for damage or leakage.             |
| Terminals      | Inspect for physical damage.                                                                 |
| Transformers   | Inspect for damage.                                                                          |
| Electron Tubes | Check for shorted or gaseous tubes. Check for bent pins.                                     |
| Switches       | Check for ease of operation. Check for burned contacts.                                      |
| Fuses          | Check for burned out fuses.                                                                  |
| Tube Sockets   | Check for damaged sockets. Check for burned connections.                                     |
| Meters         | Check for cracked glass, or damaged case. Check terminals for burned or damaged connections. |

Figure 6-1. Inspection

SECTION VII  
REPAIR OR REPLACEMENT

## 7-1. GENERAL.

7-2. The repair or replacement of components in the phase meter consist of removing the attaching hardware or unsoldering the leads. The removing of attaching hardware is obvious, therefore, this section will pertain to the unsoldering and resoldering of the leads. Replace soldered components in accordance with the following.

a. Solder joints shall be neat and smooth, without pin holes, peaks or sharp protrusions. The solder surface shall be bright, glossy and flux-free. Use materials only as specified below, or, approved equivalents. Do not use touch-up enamel on internal mechanisms and external slide mating surfaces of mating parts.

b. The following materials are to be used when replacing a part: Flux cored solder of 0.043-inch diameter or liquid flux may be used in place of the cored solder; Isopropylalcohol; clear insulating touch-up enamel; solvent (for touch-up enamel).

c. After locating defective component(s), carefully remove the part(s) without disturbing the adjacent components or their protective coating. When defective component(s) incorporate(s) common solder junctions with other components, do not disturb the common joints unless the terminal leads of the defective part cannot be used as splice stubs for replacement part. Upon removal of desired parts, take the following steps in exact sequence to install the replacement part.

d. Thoroughly clean all disturbed terminations by abrading or scraping the protective coating from the intended connection surface.

e. Wipe the terminal surfaces with a clean cloth dampened with alcohol.

f. Insert replacement part in identical location and disposition as previous part, or in specified new location. Resultant lead lengths and required insulation should closely approximate the amounts and types used on the original installation.

g. Complete splices by mechanical methods (hook, twist, insertion, etc.) and replace any component supports. Solder junctions using material specified. Use conductive transfer heating methods, only, in the replacement of parts, i.e. irons, guns, pencils, etc. Do not apply direct flame to any of the components.

## CAUTION

The maximum temperature resistance of the majority of the components involved range to 250°F (121°C). Exercise care that soldering operations at terminations do not result in excessive thermal transfer through leads or supporting members.

h. Wash flux residues from solder joints with alcohol and recoat all disturbed components and junctions with insulating enamel by brush application of a mixture of three parts enamel to two parts solvent.

## SECTION VIII

## REASSEMBLY AND TESTING OF ASSEMBLIES AND SUBASSEMBLIES

## 8-1. REASSEMBLY.

8-2. The reassembly of the assemblies and sub-assemblies contained in the phasemeter is essentially the reverse of disassembly. Refer to figures 4-3 through 4-11 for disassembly sequence.

## 8-3. TESTING.

8-4. There are no tests to be made on the individual assemblies of the phasemeter.

## SECTION IX

## REASSEMBLY AND TESTING OF COMPONENTS

## 9-1. REASSEMBLY.

9-2. PHASEMETER ASSEMBLY. Reassemble the phasemeter assembly in the reverse order of disassembly. Refer to figure 4-2 for disassembly sequence.

9-3. POWER SUPPLY. Reassemble the power supply unit in the reverse order of disassembly. Refer to figure 4-12 for disassembly sequence.

## 9-4. TESTING COMPONENTS.

9-5. There are no tests required on the individual components. The complete phasemeter should be tested as a unit. Refer to Section XI for complete testing procedure.

## SECTION X

## FINAL ASSEMBLY

## 10-1. FINAL ASSEMBLY.

10-2. The power supply unit (2, figure 4-1) is installed on the lower rack of the case (3). The phase-

meter assembly (1) is then installed in the top rack and electrically connected to the power supply. Refer to Section XI for final inspection and performance test.



SECTION XI  
INSPECTION, TESTING AND PACKAGING

## 11-1. FINAL INSPECTION.

11-2. The final inspection is a general inspection of the precision phasemeter for the following:

a. Inspect case for physical damage, loose or damaged hardware and loose components.

b. Inspect the general condition of the painted surfaces. They should be covered to prevent rust and corrosion.

c. Marking of the equipment required by technical orders or other instructions, to indicate overhaul, or the incorporation of changes, shall be applied during inspection and test.

## 11-3. PERFORMANCE TEST.

11-4. The Model 901/1010 Phasemeter Assembly is correctly aligned and calibrated at the factory, and all that is normally required prior to operation is to calibrate the unit externally in accordance with the procedure outlined in paragraph 11-6. However, it is necessary periodically to determine that the performance characteristics of the Phasemeter are still within the specified tolerances. For this check a test method capable of disclosing errors on the order of 0.01 degree is necessary. Such order of accuracy cannot be obtained throughout the frequency and angular ranges of the instrument by means of any test equipment now available. In the case of a single 45-degree R-C network, the required component tolerances would be approximately 1.75 parts per 10,000. Such a network would be suitable for use at only one frequency, and would itself require calibration equipment of extreme complexity.

A phase standard of zero degrees is required. This is obtained by merely connecting the two Phasemeter inputs to a single signal source. In addition, two uncalibrated variable phase shifters are required. Their input and output impedances must be sufficiently high and low, respectively, so that loading one output with the other input introduces less than 0.01-degree phase change. The output impedances must also be sufficiently low so that less than 0.01-degree change results when the Precision Phasemeter input circuit is used as a load for either phase shifter.

The procedure for making the alignment check is outlined in paragraph 11-5 and the required test circuit is given in figure 11-1.

## 11-5. PHASEMETER ALIGNMENT PROCEDURE.

Phasemeter accuracy should be rechecked at least every six months in accordance with the following procedure. The only additional equipment required includes the two uncalibrated phase shifters described in paragraph 11-4 and an audio oscillator (General Radio Type 1301-A or equivalent). The required characteristics of the phase shift networks are noted on the schematic diagram of the alignment test circuit, figure 11-1.

## a. Initial Control Settings.

1. Power switch (S901) in OFF position.
2. DEGREES control (Z801) at 0 degrees.
3. PHASE - CALIBRATE switch (S802) in CALIBRATE position.
4. BALANCE COMPARE switch (S803) in ZERO position.
5. DEGREES meter SET control (R801) in mid-position.
6. Phase sense switch (S807) in +0° position.
7. Frequency multiplier switch (S804) in CPS X-1 position.
8. BALANCE METER NULL and DEGREES METER NULL COARSE controls (R812 and R817) at 30 cps.
9. UNKNOWN LEVEL meter control (R805) maximum CCW.
10. REFERENCE LEVEL meter control R806) maximum CCW.
11. BALANCE meter ZERO control (R811) in mid-position.
12. BALANCE meter SET control (R807) in mid-position.

## b. External Calibration.

1. Apply 60 cps, 115V ac power and allow a two-hour warm-up period.

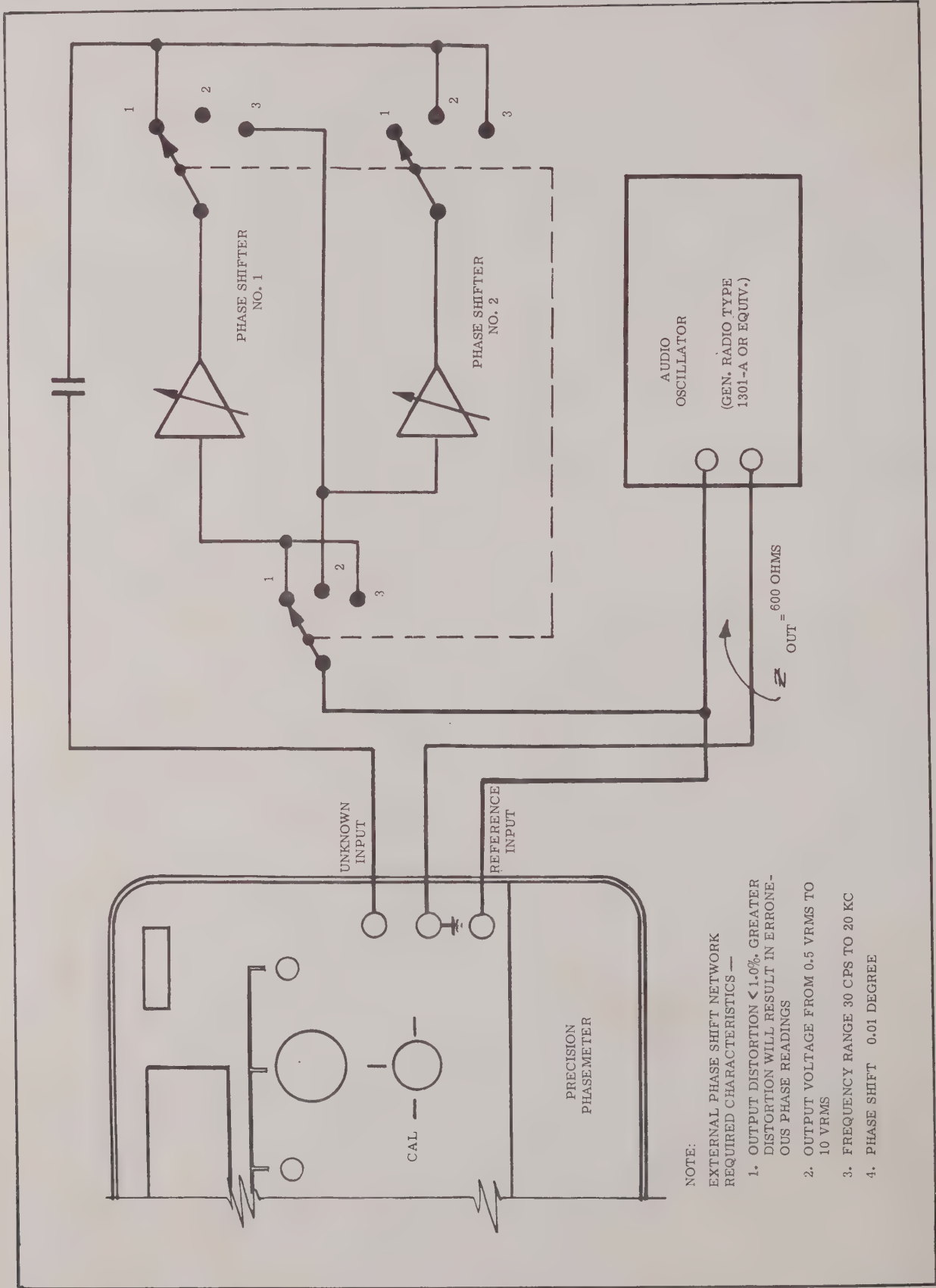


Figure 11-1. Test Circuit

2. Then apply 0.5 Vrms, 30-cps test signal to the REFERENCE INPUT terminal of Phasemeter.

3. Adjust BALANCE ZERO control (R811) until the BALANCE meter (M805) indicator is on the red line. Rotate the DEGREES meter switch (S801) to the X-1 position. Readjust the BALANCE ZERO control until the BALANCE meter indicator is on the red line. Rotate the DEGREES meter switch (S801) to X-10.

4. Adjust the REFERENCE LEVEL control (R806) until the REFERENCE meter (M804) indicator is on the red line.

5. Adjust the BALANCE SET control (R807) until the BALANCE METER (M805) indicator is on the red line. Rotate the DEGREES meter switch (S801) to X-1. Readjust the BALANCE SET control (R807) until the BALANCE meter (M805) indicator is on the red line.

6. Adjust the DEGREES meter SET control (R801) until the DEGREES meter (M801) reads exactly 0 degrees. Rotate the DEGREES meter switch (S801) to the X-10 position.

7. Switch the BALANCE <sup>ZERO</sup> COMPARE switch (S803) to COMPARE.

8. Advance the UNKNOWN LEVEL control (R805) CW until the UNKNOWN meter (M803) indicator is on the red line.

9. Adjust the BALANCE METER NULL controls COARSE, MEDIUM, and FINE (R812, R814, R816) until the BALANCE meter indicator is on the red line.

10. Adjust the DEGREES METER NULL controls COARSE, MEDIUM, and FINE (R817, R819, R821) until the DEGREES meter (M801) indicates 0 degrees.

11. Set the DEGREES meter switch (S801) to X-1 and repeat steps 9 and 10 of paragraph 11-5, b, above. Place the DEGREES meter switch (S801) at X-10.

12. Decrease the UNKNOWN LEVEL and REFERENCE LEVEL controls (R805, R806) to a maximum CCW position.

#### c. Preliminary Phasemeter Tests.

##### 1. METER SENSE (M802) Test.

(a) Jump the Phasemeter UNKNOWN and REFERENCE INPUT terminals together.

(b) Repeat the external calibration procedure outlines in paragraph 11-5, b, steps 2 through 12, above. The METER SENSE (M802) should indicate

ADD 0 degrees. METER SENSE polarity is independent of input frequency and amplitude.

#### 2. PHASE LAG, PHASE LEAD, CALIBRATE TEST.

(a) Recalibrate Phasemeter externally as outlined in paragraph 11-5, b, steps 2 through 12.

(b) Rotate PHASE - CALIBRATE switch (S802) to PHASE LAG position.

(c) Increase the UNKNOWN LEVEL and REFERENCE LEVEL controls (R805, R806) until the indicators of the UNKNOWN and REFERENCE meters (M803, M804) are on the red lines.

(d) Rotate the DEGREES meter switch (S801) to X-1. The DEGREES meter (M801) will read zero. This measurement is independent of input frequency and amplitude.

(e) Rotate the DEGREES meter switch (S801) to X-10. Decrease the UNKNOWN LEVEL and REFERENCE LEVEL controls (R805, R806) and rotate the PHASE - CALIBRATE switch (S802) to PHASE LEAD.

(f) Repeat steps (c) and (d) of this test. Resultant measurement is the same now as before for step d.

#### d. Phase Measurements: 2-Degree Test.

1. Remove common jumper connection between REFERENCE AND UNKNOWN INPUT terminals on the Phasemeter front panel. Calibrate the Phasemeter as outlined in paragraph 11-5, b, steps 2 through 12, above.

2. Rotate the PHASE - CALIBRATE switch (S802) to PHASE LAG.

3. Connect one of the variable phase shift network outputs to the phasemeter UNKNOWN INPUT terminal. Refer to figure 11-1.

4. Advance the REFERENCE LEVEL control (R806) until the indicator of the REFERENCE meter (M804) is on the red line.

5. While carefully advancing the UNKNOWN LEVEL control (R805) to bring the indicator of the UNKNOWN meter (M803) to the red line, vary the phase shifter output until the DEGREES meter (M801) indicates plus 0.10 degree.

6. Rotate the DEGREES meter switch (S801) to X-1 and readjust the phase shifter until the DEGREES meter (M801) indicates exactly plus 1.0 degree.

7. Advance the DEGREES control (Z801) to 44 degrees. The DEGREES meter (M801) will indicate a negative 1.0 degree. To compensate for any phase errors observed at this point, adjust R802 (screw-driver adjust).

#### NOTE

If R802 is adjusted, the external calibration procedure outlined in paragraph 11-5, b, steps 2 through 12, above, as well as the 2-degree test itself, must be repeated.

8. After the 2-degree test has been completed at 30 cps with a 0.5 V rms input, repeat it at 300 cps, 3 kc, and 20 kc.

9. After all the tests in step 8 above, have been completed, repeat them at each of the four signal frequencies with an input of 10.0 V rms.

#### NOTE

An additional capacitor is to be added in shunt with C810 to trim to the 2-degree test at 2kc and 20kc. The capacitance value of the trimmer will be in the order of 2500 uff, and its voltage rating should be 100 WV dc, minimum.

10. Upon completion of the 2-degree test at all frequencies at both input levels, decrease the UNKNOWN LEVEL and REFERENCE LEVEL controls (R805, R806) maximum CCW and rotate the phase-calibrate switch (S802) to CALIBRATE.

#### e. Phase Measurements: 44-46 Degree Test.

1. Calibrate Phasemeter as outlined in paragraph 11-5, b, steps 2 through 12. Advance the DEGREES control (Z801) to 44 degrees.

2. Repeat steps 2 through 6 of the 2-degree test, paragraph 11-5, d, above. Decrease the UNKNOWN LEVEL control (R805) and rotate the DEGREES meter switch (S801) to X-10.

3. Advance the DEGREES meter switch (S801) to 46 degrees. Advance the UNKNOWN LEVEL control (R805) until the UNKNOWN meter (M803) indicator is on the red line. Rotate the DEGREES meter switch (S801) to X-1. The DEGREES meter (801) will indicate a negative 1.0 degree.

4. To compensate for any phase error observed in the 44-46 degree test, the following tube  $G_m$  balance must be observed for the adder and phase shifter calibration:

V301 and V303:-  $G_m$  match of first half of (5751) tubes, pins 1, 2, and 3, respectively, must be within 5%.

V302 and V304:-  $G_m$  match of second half of tubes, pins 6, 7, and 8, respectively, must be within 5%.

5. After completing the above 44-46 degree test at 30 cps, 0.5 V rms, repeat it at 300 cps, 3kc, and 20 kc.

6. Repeat the 44-46 degree test as outlined in paragraph 2, e, steps 1 through 5, with an input level of 10.0 V rms.

#### f. 90-Amplifier Test.

1. Repeat steps 1 through 10, paragraph 11-5, b.

2. Observe the wave shape on V503 (6AU6WA) pin 5. A 30-cps sinusoidal wave shape should appear on the plate of V503. If a sawtooth oscillation is noted, replace the 6AU6WA and/or the VR-57, depending upon which tube is required to correct the sawtooth condition.

#### g. Phase Error Tests: Single 90-Degree Test.

1. With the DEGREES control (Z801) set at 90 degrees, repeat steps 2 through 12 of paragraph 11-5, b.

2. Rotate PHASE - CALIBRATE switch (S802) to PHASE LAG.

3. Connect the output of external phase shift network No. 1 to the Phasemeter UNKNOWN INPUT terminal.

4. Advance the REFERENCE LEVEL control (R806) until the REFERENCE meter (M804) indicator is on the red line.

5. While carefully advancing the UNKNOWN LEVEL control (R805) to bring the indicator of the UNKNOWN meter (M803) to the red line, vary the external phase shifter output until the DEGREES meter (M801) indicates zero degrees with the DEGREES meter switch (S801) in the X-1 position.

6. Decrease the UNKNOWN LEVEL control (R805) and rotate the DEGREES meter switch (S801) to X-10.

7. Set the PHASE - CALIBRATE switch (S802) to PHASE LEAD. Rotate the phase sense switch (S807) to +180°.

8. Advance the UNKNOWN LEVEL control (R805) until the UNKNOWN meter (M803) indicator is on the red line.

9. Rotate the DEGREES meter switch (S801) to X-1.

10. Observe the indicated phase error. Calculate the single 90-degree error as follows:

DEGREES meter indication (degrees)  $\times$  0.5 = single 90-degree absolute error (degrees).

11. Repeat the entire single 90-degree test at 300 cps, 3 kc, and 20 kc with an input of 0.5 V rms.

12. Repeat the entire 90-degree test at 30 cps, 300 cps, 3 kc, and 20 kc with a 10.0 V rms.

#### h. Phase Error Tests: Double 90-Degree Test.

1. Set DEGREES control (Z801) to 90 degrees and repeat steps 2 through 12 of paragraph 11-5, b.

2. Repeat steps 2 through 6 of the single 90-degree test, paragraph 11-5, g.

3. Then, without disturbing the phase setting of external phase shifter No. 1, connect the second external variable phase shifter network output to the Phasemeter UNKNOWN INPUT terminal, and repeat steps 5 and 6 of paragraph 11-5, g.

4. Connect the No. 1 phase shifter in series with the No. 2 phase shifter, connecting the combined phase shift output to the Phasemeter UNKNOWN INPUT terminal.

5. Rotate the Phasemeter DEGREES control (Z801) to 0 degrees.

6. Rotate the phase sense switch (S807) to the +180° position.

7. Advance UNKNOWN LEVEL and REFERENCE LEVEL controls (R805, R806) until the indicators of the UNKNOWN and REFERENCE meters (M803, M804) are on the red line. Rotate the DEGREES meter switch (S801) to X-1.

8. Observe the indicated phase error. Calculate the double 90-degree phase error as follows:

DEGREES meter indication (degrees)  $\times$  0.5 = double 90-degree, absolute error (degrees). This is also known as the 90-degree calculated error.

9. Repeat the double 90-degree test at 300 cps, 3 kc, and 20 kc at an input of 0.5 V rms.

10. After completing step 9, repeat the double 90-degree test at the four frequencies using a 10.0 V rms input.

#### i. Phase Error Tests: Double 180-Degree Test.

1. Repeat steps 1 through 8 of the double 90-degree test, paragraph 11-5, h.

2. Vary the external phase shifter No. 1 or No. 2 until the DEGREES meter (M801) reads 0 degrees with the DEGREES meter switch (S801) in the X-1 position.

3. Decrease the UNKNOWN LEVEL and the REFERENCE LEVEL controls (R805, R806) and rotate the phase-calibrate switch (S802) to PHASE LEAD.

4. Advance the UNKNOWN LEVEL and REFERENCE LEVEL controls (R805, R806) until the indicators of their associated meters are on the red line.

5. Rotate the DEGREES meter switch (S801) to the X-1 position.

6. Observe the indicated phase error. Calculate the double 180-degree error as follows:

DEGREES meter indication (degrees)  $\times$  0.5 = double 180-degree absolute error (degrees).

#### NOTE

The double 180-degree error will be excessive if the Phasemeter input harmonic content exceeds 1.0%.

7. Repeat the double 180-degree test at 300 cps, 3 kc, and 20 kc with an input of 0.5 V rms.

8. Repeat the double 180-degree test at 30 cps, 300 cps, and 20 kc using a 10.0 V rms input.

#### j. Phase Error Tests: Double 44-Degree Tests.

1. Set the DEGREES control (Z801) at 44 degrees and repeat steps 2 through 12 of paragraph 11-5, b. Repeat paragraph 11-5, g, steps 2 through 6.

2. Without disturbing the setting of the No. 1 phase shifter, connect the output of the No. 2 phase shifter to the Phasemeter UNKNOWN INPUT terminal.

3. Repeat steps 4 through 6 of paragraph 2, g, above.

4. Connect phase shifter No. 1 in series with phase shifter No. 2 and connect the combined output to the Phasemeter UNKNOWN INPUT terminal.

5. Advance the DEGREES control (Z801) to 88 degrees.

6. Advance the UNKNOWN LEVEL and REFERENCE LEVEL controls (R805, R806) until the indicators of the associated meters are on the red line.

7. Rotate the DEGREES meter switch (S801) to X-1.

8. Observe the phase error indicated on the DEGREES meter (M801). Calculate the double 44-degree phase error as follows:

DEGREES meter (M801) indication (degrees) x 0.5 + 90-degree calculated error (as found in step 10, paragraph 2, g, above) = 44-degree calculated error.

NOTE

The 44-degree calculated error is defined as an absolute error.

9. After completion of the double 44-degree test at 30 cps, repeat it at 300 cps, 3 kc, and 20 kc with a 0.5 V rms input.

10. Repeat the 44-degree test at 30 cps, 300 cps, 3 kc, and 20 kc with a 10.0 V rms input.

k. Phase Error Tests: Double 22-Degree Test.

1. Set the DEGREES control (Z801) at 22 degrees and repeat steps 1 through 6 of paragraph 2, g, above.

2. Without disturbing the setting of phase shifter No. 1, connect the output of phase shifter No. 2 to the Phasemeter UNKNOWN INPUT terminal.

3. Repeat steps 4 through 6 of paragraph 11-5, g, above.

4. Connect phase shifters No. 1 and No. 2 in series and connect the combined output to the Phasemeter UNKNOWN INPUT terminal.

5. Advance the DEGREES control (Z801) to 44 degrees.

6. Advance the UNKNOWN LEVEL and REFERENCE LEVEL controls (R805, R806) until the indicators of the associated meters are on the red line.

7. Rotate the DEGREES meter switch (S801) to X-1.

8. Observe the phase error indicated on the DEGREES meter (M801). Calculate the double 22-degree phase error as follows:

DEGREES meter indication (degrees) x 0.5 + 44 degrees calculated error (as found in step 8, paragraph 2, j, above) = 22-degree calculated error (degrees).

NOTE

The 22-degree calculated error is defined as an absolute error.

9. After completion of the double 22-degree test at 30 cps, repeat the double 22-degree test at 300 cps, 3 kc, and 20 kc with an input of 0.5 V rms.

10. Repeat the double 22-degree test at 30 cps, 300 cps, 3 kc, and 20 kc with an input of 10.0 V rms.

11-6. VOLTAGE AND RESISTANCE MEASUREMENTS.

Figures 11-2 and 11-3, respectively, list typical voltage and resistance measurements made on the Model 901/1010 Phasemeter. Some small variations from the tabulated readings will normally be found, particularly in grid circuit voltages. Before proceeding with measurements, the following items should be noted:

a. All voltage measurements are made with a high-impedance vacuum-tube voltmeter (RCA Voltomyst or equivalent).

b. Voltage readings are made with no input signals applied to the Phasemeter, and with 117 volts, 60 cps line voltage.

c. All voltages listed are positive d-c values, except where otherwise noted.

d. All readings are made with respect to signal ground.

e. All resistance values are in ohms unless otherwise noted.

f. All measurements are made with the following Phasemeter control settings:

| Control                          | Settings                                |
|----------------------------------|-----------------------------------------|
| Multiplier switch (S804)         | CPS X-1                                 |
| Phase-Calibrate switch (S802)    | CALIBRATE                               |
| BALANCE ZERO control (R811)      | Approximately at mid-point of rotation. |
| BALANCE SET control (R807)       | Approximately at mid-point of rotation. |
| DEGREES Meter SET control (R801) | Approximately at mid-point of rotation. |
| DEGREES Meter switch (S801)      | X-10.                                   |
| All other controls               | Fully counter-clockwise.                |

## 11-7. CALIBRATION.

a. Make certain that all controls are set as described in Figure 11-4.

b. If the input signals have not yet been connected to the Phasemeter Assembly, connect one of them, or any signal of precisely the frequency at which measurements are to be made, between the REFERENCE and ground input terminals.

c. Adjust BALANCE ZERO control (R811) so that BALANCE meter reads to red line.

d. Set DEGREES meter switch (S801) to X-1 and repeat step c. Return switch to X-10.

e. Turn REFERENCE LEVEL potentiometer clockwise until REFERENCE LEVEL meter reads to red line.

f. Adjust DEGREES meter SET control (R801) that DEGREES meter reads 0.

g. Adjust BALANCE SET control (R807) so that BALANCE meter reads to red line.

| DESIG-<br>NATION | 1    | 2    | 3    | PIN NUMBER<br>4 | 5    | 6    | 7    | 8    | 9   |
|------------------|------|------|------|-----------------|------|------|------|------|-----|
| V101             | 0    | 0    | 0    | 0               | 0    | 0    | 0    | 0    | --  |
| V102             | 240  | 0    | 0    | HTR             | HTR  | 220  | 17.0 | 20.0 | HTR |
| V103             | 74.0 | 3.20 | 4.2  | HTR             | HTR  | 65.0 | 3.20 | 4.00 | HTR |
| V104             | 250  | 2.50 | 6.00 | HTR             | HTR  | 250  | 2.50 | 5.60 | HTR |
| V105             | 230  | 6.00 | 7.00 | HTR             | HTR  | 230  | 5.60 | 7.00 | HTR |
| V201             | 120  | 0    | 1.80 | HTR             | HTR  | 180  | 48.0 | 52.0 | HTR |
| V202             | 0    | 5.60 | HTR  | HTR             | 116  | 92.0 | 1.80 |      |     |
| V203             | 240  | 0    | 4.30 | HTR             | HTR  | 240  | 0    | 4.30 | HTR |
| V204             | 120  | 0    | 1.80 | HTR             | HTR  | 175  | 47.0 | 53.0 | HTR |
| V205             | 0    | 0    | HTR  | HTR             | 116  | 80.0 | 1.80 |      |     |
| V206             | 235  | 0    | 4.20 | HTR             | HTR  | 235  | 0    | 4.20 | HTR |
| V207             | 235  | 3.80 | 8.00 | HTR             | HTR  | 235  | 3.80 | 8.00 | HTR |
| V301             | 175  | 0    | 1.26 | HTR             | HTR  | 175  | 0    | 2.20 | HTR |
| V302             | 0    | 0    | 0    | HTR             | HTR  | 250  | 0    | 1.24 | HTR |
| V303             | 180  | 0    | 1.12 | HTR             | HTR  | 180  | 0    | 2.00 | HTR |
| V304             | 0    | 0    | 0    | HTR             | HTR  | 250  | 0    | 2.00 | HTR |
| V305             | 175  | 0    | 0    | HTR             | HTR  | 220  | 17.0 | 19.0 | HTR |
| V306             | 250  | 18.0 | 40.8 | HTR             | HTR  | 250  | 17.0 | 35.0 | HTR |
| V401             | 250  | 17.0 | 33.0 | HTR             | HTR  | 0    | 0    | 0    | HTR |
| V402             | 250  | 17.0 | 33.0 | HTR             | HTR  | 0    | 0    | 0    | HTR |
| V501             | 250  | 14.0 | 25.0 | HTR             | HTR  | 250  | 0    | 3.10 | HTR |
| V502             | 250  | 3.00 | 4.50 | HTR             | HTR  | 90.0 | 3.50 | 4.80 | HTR |
| V503             | 0    | 1.20 | HTR  | HTR             | 64.0 | 50.0 | 1.20 | --   | --  |
| V504             | 250  | 10.0 | 13.3 | HTR             | HTR  | 250  | 10.0 | 13.0 | HTR |
| V505             | 250  | 10.0 | 13.0 | HTR             | HTR  | 250  | 10.0 | 13.0 | HTR |
| V601             | 250  | 14.0 | 24.0 | HTR             | HTR  | 195  | 34.0 | 39.0 | HTR |
| V602             | 120  | 0    | 1.80 | HTR             | HTR  | 120  | 0    | 1.80 | HTR |
| V603             | 245  | 0    | 2.60 | HTR             | HTR  | 245  | 0    | 2.60 | HTR |
| V701             | 215  | 0    | 2.20 | HTR             | HTR  | 215  | 0    | 2.20 | HTR |
| V901             | 0    | 240  | 0    | 0               | 400  | 0    | 0    | 0    | --  |
| V902             | 0    | HTR  | 390  | 500             | 225  | 0    | HTR  | 240  | --  |
| V903             | 0    | HTR  | 390  | 500             | 225  | 0    | HTR  | 240  | --  |
| V904             | 0    | HTR  | 390  | 500             | 225  | 0    | HTR  | 240  | --  |
| V905             | 0    | 0    | 0    | 0               | 108  | 0    | 0    | --   | --  |
| V906             | 0    | 0    | 0    | 0               | 85   | 0    | 0    | --   | --  |
| V907             | 105  | 108  | HTR  | HTR             | 220  | 150  | 108  | --   | --  |
| V908             | 105  | 85   | 86   | HTR             | HTR  | 105  | 85   | 86   | HTR |

Figure 11-2. Voltage Measurements

| DESIGN-<br>NATION                                                                           | PIN NUMBER |      |      |     |      |      |      |      |     |
|---------------------------------------------------------------------------------------------|------------|------|------|-----|------|------|------|------|-----|
|                                                                                             | 1          | 2    | 3    | 4   | 5    | 6    | 7    | 8    | 9   |
| V101                                                                                        | Inf        | 350  | 350  | Inf | 700  | 400  | 400  | 700  | --  |
| V102                                                                                        | Inf        | Inf  | Inf  | HTR | HTR  | 25K  | 100K | 11K  | HTR |
| V104                                                                                        | 12K        | 1M   |      |     |      |      |      |      |     |
| V104                                                                                        | 12K        | 1Meg | 5K   | HTR | HTR  | 6.2K | 1Meg | 5K   | HTR |
| V105                                                                                        | 12K        | 6K   | 330  | HTR | HTR  | 12K  | 6K   | 330  | HTR |
| V202                                                                                        |            |      |      |     |      |      |      |      |     |
| V202                                                                                        | 1Meg       | 680  | HTR  | HTR | 50K  | 200K | 680  | --   | --  |
| V204                                                                                        | 530K       | 1Meg | 22K  | HTR |      |      |      |      |     |
| V204                                                                                        | 530K       | 1Meg | 2.7K | HTR | HTR  | 140K | 1Meg | 100K | HTR |
| V205                                                                                        | 1Meg       | 680  | HTR  | HTR | 100K | 220K | 680  | --   | --  |
| V206                                                                                        | 12K        | 1Meg | 22K  | HTR | HTR  | 12K  | 1Meg | 22K  | HTR |
| V207                                                                                        | 12K        | 1Meg | 50K  | HTR | HTR  | 12K  | 1Meg | 50K  | HTR |
| V301                                                                                        | 40K        | 1Meg | 200  | HTR | HTR  | 8.5K | 1Meg | 2.7K | HTR |
| V302                                                                                        | Inf        | Inf  | Inf  | HTR | HTR  | 12K  | 1Meg | 200  | HTR |
| V303                                                                                        | 40K        | 1Meg | 200  | HTR | HTR  | 8.5K | 8K   | 1Meg | HTR |
| V304                                                                                        | Inf        | Inf  | Inf  | HTR | HTR  | 12K  | 1Meg | 200  | HTR |
| V305                                                                                        | 85K        | 1Meg | 2.7K | HTR | HTR  | 30K  | 110K | 11K  | HTR |
| V306                                                                                        | 12K        | 1Meg | 5K   | HTR | HTR  | 12K  | 1Meg | 5K   | HTR |
| V402                                                                                        | 12K        | 1Meg | 5K   | HTR | HTR  | Inf  | Inf  | Inf  | HTR |
| V501                                                                                        | 12K        | 1Meg | 6K   | HTR | HTR  | 12K  | 100K | 1K   | HTR |
| V502                                                                                        | 12K        | 16K  | 1.5K | HTR | HTR  | 500K | 2.2K | 1.5K | HTR |
| V503                                                                                        | 1Meg       | 820  | HTR  | HTR | 180K | 500K | 820  |      |     |
| V504                                                                                        | 12K        | 300K | 1K   | HTR | HTR  | 12K  | 300K | 1K   | HTR |
| V505                                                                                        | 12K        | 300K | 1K   | HTR | HTR  | 12K  | 300K | 1K   | HTR |
| V601                                                                                        | 12K        | 1Meg | 5.6K | HTR | HTR  | 24K  | 100K | 11K  | HTR |
| V602                                                                                        | 500K       | 1Meg | 2.7K | HTR | HTR  | 500K | 1Meg | 2.7K | HTR |
| V603                                                                                        | 12K        | 1Meg | 200  | HTR | HTR  | 12K  | 1Meg | 200  | HTR |
| V701                                                                                        | 18K        | 1Meg | 510  | HTR | HTR  | 18K  | 1Meg | 510  | HTR |
| NOTE: Power Supply resistance measurements below are made with connector P902 disconnected. |            |      |      |     |      |      |      |      |     |
| V901                                                                                        | Inf        | 45K  | Inf  | Inf | 65K  | Inf  | Inf  | Inf  | --  |
| V902                                                                                        | Inf        | Inf  | Inf  | 70K | 400K | Inf  | Inf  | 45K  | --  |
| V903                                                                                        | Inf        | Inf  | Inf  | 70K | 400K | Inf  | Inf  | 45K  | --  |
| V904                                                                                        | Inf        | Inf  | Inf  | 70K | 400K | Inf  | Inf  | 45K  | --  |
| V905                                                                                        | Inf        | 0    | Inf  | Inf | 60K  | Inf  | Inf  | --   | --  |
| V906                                                                                        | Inf        | 0    | Inf  | Inf | 100K | Inf  | Inf  | --   | --  |
| V907                                                                                        | 1Meg       | 60K  | 60K  | 60K | 400K | 60K  | 60K  | --   | --  |
| V908                                                                                        | 1Meg       | 100K | 220K | 60K | 60K  | 60K  | 15K  | 220K | 60K |

Figure 11-3. Resistance Measurements

h. Set DEGREES meter switch (S801) to X-1 and repeat steps f and g. Return switch to X-10.

i. Adjust BALANCE switch to COMPARE.

j. Now adjust the BALANCE METER NULL COARSE and MEDIUM controls so that BALANCE meter reads to red line.

k. If necessary, readjust REFERENCE LEVEL potentiometer so that REFERENCE meter reads to red line.

l. Set DEGREES meter switch (S801) to X-1. Adjust BALANCE METER NULL MEDIUM and FINE controls so that BALANCE meter reads to red line.

m. Return DEGREES meter switch (S801) to X-10.

### CAUTION

Never set DEGREES meter switch (S801) to the X-1 position unless, with this switch set to X-10, the DEGREES meter reads  $\pm 0.10$  degrees.

n. Turn UNKNOWN LEVEL control clockwise until UNKNOWN meter (M803) reads to red line.

o. Adjust the DEGREES METER NULL COARSE and MEDIUM controls so that DEGREES meter reads zero.

p. If necessary, readjust REFERENCE LEVEL and UNKNOWN LEVEL controls so that each of the corresponding LEVEL meters reads to red line.

q. Set DEGREES meter switch to X-1. Set DEGREES METER NULL MEDIUM and FINE controls so that DEGREES meter reads zero.

v. Return DEGREES meter switch to X-10. The Precision Phasemeter is now calibrated, and phase measurements may be made.

| Control                                             | Setting                                                                                                                                                                                                                                                                                                                              |            |       |         |      |        |           |       |          |            |
|-----------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|-------|---------|------|--------|-----------|-------|----------|------------|
| REFERENCE LEVEL potentiometer                       | Fully counterclockwise.                                                                                                                                                                                                                                                                                                              |            |       |         |      |        |           |       |          |            |
| UNKNOWN LEVEL potentiometer                         | Fully counterclockwise.                                                                                                                                                                                                                                                                                                              |            |       |         |      |        |           |       |          |            |
| Phase sense switch (S807)                           | Add 0°                                                                                                                                                                                                                                                                                                                               |            |       |         |      |        |           |       |          |            |
| DEGREES meter switch (S801)                         | X-10                                                                                                                                                                                                                                                                                                                                 |            |       |         |      |        |           |       |          |            |
| DEGREES control (Z801)                              | 0                                                                                                                                                                                                                                                                                                                                    |            |       |         |      |        |           |       |          |            |
| PHASE LAG - PHASE LEAD -<br>CALIBRATE switch (S802) | CALIBRATE                                                                                                                                                                                                                                                                                                                            |            |       |         |      |        |           |       |          |            |
| BALANCE COMPARE switch (S803)                       | ZERO                                                                                                                                                                                                                                                                                                                                 |            |       |         |      |        |           |       |          |            |
| Multiplier switch (S804):<br>CPS X-1, X-10, X-100   | Set to proper position for frequency at which measurement is to be made. The switch positions correspond to frequency ranges as follows:<br><br><table><tr><td>X-1</td><td>30 to</td><td>300 cps</td></tr><tr><td>X-10</td><td>300 to</td><td>3,000 cps</td></tr><tr><td>X-100</td><td>3,000 to</td><td>20,000 cps</td></tr></table> | X-1        | 30 to | 300 cps | X-10 | 300 to | 3,000 cps | X-100 | 3,000 to | 20,000 cps |
| X-1                                                 | 30 to                                                                                                                                                                                                                                                                                                                                | 300 cps    |       |         |      |        |           |       |          |            |
| X-10                                                | 300 to                                                                                                                                                                                                                                                                                                                               | 3,000 cps  |       |         |      |        |           |       |          |            |
| X-100                                               | 3,000 to                                                                                                                                                                                                                                                                                                                             | 20,000 cps |       |         |      |        |           |       |          |            |
| BALANCE METER NULL, COARSE                          | Set approximately to frequency at which measurement is to be made.                                                                                                                                                                                                                                                                   |            |       |         |      |        |           |       |          |            |
| DEGREES METER NULL, COARSE                          | Set approximately to frequency at which measurement is to be made.                                                                                                                                                                                                                                                                   |            |       |         |      |        |           |       |          |            |

Figure 11-4. Preliminary Control Settings



## SECTION V

### ELECTRICAL REPLACEABLE PARTS

This section contains a list of all replaceable electrical parts for the Precision Phasemeter Model 1010, manufactured by Maxson Instruments.

The parts list is arranged in two tables, the first dealing with the electrical parts for the phasemeter proper, the second with those for the phasemeter power supply. All parts are listed in alpha-numerical order by circuit reference

designation, as shown on the electrical schematic diagrams located in Section VI of this handbook.

The parts list is tabulated in four columns. Column 1 lists the electrical reference designation of the part. Column 2 gives a brief description of the electrical properties of the part. Columns 3 and 4 give complete ordering information, including vendor's name and part number, respectively, for replacing the part.

#### TABLE OF REPLACEABLE PARTS

#### PHASEMETER CHASSIS

| CIRCUIT<br>REFERENCE<br>DESIGNATION | DESCRIPTION                                                  | MFR'S NAME              | MFR'S<br>PART NO. |
|-------------------------------------|--------------------------------------------------------------|-------------------------|-------------------|
| C101                                | CAPACITOR, fixed: paper;<br>.047 uf $\pm 10\%$ ; 300w v d-c. | Sprague<br>Electric Co. | 65P47393          |
| C102                                | Same as C101.                                                |                         |                   |
| C103                                | Same as C101.                                                |                         |                   |
| C104                                | Same as C101.                                                |                         |                   |
| C105                                | Same as C101.                                                |                         |                   |
| C106                                | CAPACITOR, fixed: electrolytic;<br>60 ufd; 350w v d-c.       | P.R. Mallory<br>& Co.   | TC 68             |
| C201                                | CAPACITOR, fixed: paper;<br>1 uf $\pm 20\%$ ; 300w v d-c.    | Sprague<br>Electric Co. | 81P10503815       |
| C202                                | CAPACITOR, fixed: paper; .1 uf<br>$\pm 5\%$ ; 100w v d-c.    |                         |                   |
| C203                                | CAPACITOR, fixed: paper; .01 uf<br>$\pm 5\%$ ; 100w v d-c.   | Sprague<br>Electric Co. | 91P1035184        |
| C204                                | Same as C101.                                                |                         |                   |
| C205                                | CAPACITOR, fixed: 51 uuf<br>$\pm 5\%$ ; 500w v d-c.          | Elmenco                 | CM15E510J         |
| C206                                | Same as C201.                                                |                         |                   |
| C207                                | Same as C101.                                                |                         |                   |

| CIRCUIT<br>REFERENCE<br>DESIGNATION | DESIGNATION                                                 | MFR'S NAME              | MFR'S<br>PART NO. |
|-------------------------------------|-------------------------------------------------------------|-------------------------|-------------------|
| C208                                | Same as C204.                                               | Sprague<br>Electric Co. | 81P10401S15       |
| C209                                | Same as C204.                                               |                         |                   |
| C210                                | CAPACITOR, fixed: paper; .1 uf $\pm 20\%$ ;<br>100w v d-c.  |                         |                   |
| C211                                | Same as C210.                                               |                         |                   |
| C212                                | Same as C201.                                               |                         |                   |
| C213                                | Same as C202.                                               |                         |                   |
| C214                                | Same as C203.                                               |                         |                   |
| C215                                | Same as C204.                                               |                         |                   |
| C216                                | Same as C205.                                               |                         |                   |
| C217                                | Same as C101.                                               |                         |                   |
| C218                                | Same as C101.                                               |                         |                   |
| C219                                | Same as C101.                                               |                         |                   |
| C220                                | Same as C204.                                               |                         |                   |
| C221                                | Same as C210.                                               |                         |                   |
| C222                                | Same as C210.                                               |                         |                   |
| C301                                | CAPACITOR, fixed: paper; .22 uf $\pm 10\%$ ;<br>100w v d-c. | Sprague<br>Electric Co. | 91P2249184        |
| C302                                | CAPACITOR, fixed: paper; .01 uf $\pm 10\%$ ;<br>300w v d-c. | Sprague<br>Electric Co. | 65P10393          |
| C303                                | Same as C101.                                               | Elmenco                 | CM15-E-500J       |
| C304                                | CAPACITOR, fixed: mica; 50 uuf; 500w v<br>d-c.              |                         |                   |
| C305                                | Same as C301.                                               |                         |                   |
| C306                                | Same as C302.                                               |                         |                   |
| C307                                | Same as C101.                                               |                         |                   |
| C308                                | Same as C304.                                               |                         |                   |
| C309                                | Same as C101.                                               |                         |                   |

| CIRCUIT<br>REFERENCE<br>DESIGNATION | DESCRIPTION                                           | MFR'S NAME              | MFR'S<br>PART NO. |
|-------------------------------------|-------------------------------------------------------|-------------------------|-------------------|
| C310                                | CAPACITOR, fixed: paper; .05 uf;<br>400w v d-c.       | The Gudeman<br>Co.      | XF1817            |
| C311                                | Same as C101.                                         |                         |                   |
| C312                                | Same as C310.                                         |                         |                   |
| C401                                | Same as C101.                                         |                         |                   |
| C402                                | Same as C101.                                         |                         |                   |
| C501                                | Same as C310.                                         |                         |                   |
| C502                                | Same as C205.                                         | Sprague<br>Electric Co. | 91P1049384        |
| C503                                | CAPACITOR, fixed: paper;<br>.1 uf +10%; 300w v d-c.   |                         |                   |
| C504                                | Same as C302.                                         | Sangamo                 | PL-4510           |
| C505                                | CAPACITOR, fixed: electrolytic;<br>10 uf; 450w v d-c. |                         |                   |
| C506                                | CAPACITOR, fixed: mica; 240 uuf<br>+5%; 200w v d-c.   | Elmenco                 | CM20B241J         |
| C507                                | CAPACITOR, fixed: mica; 20 uuf<br>+5%; 200w v d-c.    | Elmenco                 | CM20B200J         |
| C601                                | Same as C101.                                         | The Gudeman<br>Co.      | XF1839J           |
| C602                                | Same as C101.                                         |                         |                   |
| C603                                | Same as C101.                                         |                         |                   |
| C604                                | Same as C101.                                         |                         |                   |
| C605                                | Same as C101.                                         |                         |                   |
| C606                                | Same as C101.                                         |                         |                   |
| C607                                | Same as C106.                                         |                         |                   |
| C701                                | Same as C101.                                         |                         |                   |
| C702                                | Same as C101.                                         |                         |                   |
| C703                                | CAPACITOR, fixed: paper;<br>.5 uf; 400w v d-c.        |                         |                   |

| CIRCUIT<br>REFERENCE<br>DESIGNATION | DESCRIPTION                                                           | MFR'S NAME                  | MFR'S<br>PART NO. |
|-------------------------------------|-----------------------------------------------------------------------|-----------------------------|-------------------|
| C704                                | Same as C703.                                                         |                             |                   |
| C705                                | CAPACITOR, fixed: electrolytic;<br>350 uf; 3w v d-c.                  | Aerovox<br>Corp.            | E26C136           |
| C801                                | CAPACITOR, fixed: electrolytic;<br>1000 uf; 3w v d-c.                 | Aerovox<br>Corp.            | NP                |
| C803                                | Same as C705.                                                         |                             |                   |
| C804                                | Same as C202.                                                         |                             |                   |
| C805                                | CAPACITOR, fixed: polystyrene;<br>0.01 <u>+</u> 5%; 100w v d-c.       | Good-All                    | 820-UB            |
| C806                                | Same as C805.                                                         |                             |                   |
| C807                                | CAPACITOR, fixed: paper; 0.051 uf<br><u>+</u> 5%; 100w v d-c.         | Sprague<br>Electric Co.     | 91P5135184        |
| C808                                | Same as C805.                                                         |                             |                   |
| C809                                | Same as C805.                                                         |                             |                   |
| C810                                | Same as C203.                                                         |                             |                   |
| C811                                | Same as C203.                                                         |                             |                   |
| C812                                | CAPACITOR, fixed: mica; 5100 uuf<br><u>+</u> 5%; 500w v d-c.          | Elmenco                     | CM35E512J         |
| C813                                | CAPACITOR, fixed: .005 uf <u>+</u> 5%;<br>100w v d-c.                 | Good-All                    | Type 820-UB       |
| C814                                | CAPACITOR, fixed: .05 uf <u>+</u> 5%;<br>100w v d-c.                  | Good-All                    | Type 820-UB       |
| C815                                | CAPACITOR, fixed: .5 uf <u>+</u> 5%;<br>100w v d-c.                   | Good-All                    | Type 820-UB       |
| C816                                | CAPACITOR, fixed: mica; 3700 uuf<br>approx (value determined at cal). |                             | CM35E122K         |
| V501                                | VOLTAGE REGULATOR TUBE                                                | VICTOREEN<br>Instrument Co. | VR-57             |
| CR701                               | RECTIFIER                                                             | Conant<br>Laboratories      | 160-BH8           |
| CR702                               | Same as CR701.                                                        |                             |                   |
| I501                                | NEON LAMP                                                             |                             | NE2               |

| CIRCUIT<br>REFERENCE<br>DESIGNATION | DESCRIPTION              | MFR'S NAME                   | MFR'S<br>PART NO. |
|-------------------------------------|--------------------------|------------------------------|-------------------|
| J101                                | CONNECTOR.               | Continental<br>Connector Co. | 18-16P            |
| J201                                | CONNECTOR.               | Continental<br>Connector Co. | 10-16P            |
| J301                                | Same as J201.            |                              |                   |
| J401                                | CONNECTOR                | Continental<br>Connector Co. | 7-16P             |
| J501                                | Same as J201.            |                              |                   |
| J502                                | TIP JACK.                | E. F. Johnson                | 105-601           |
| J601                                | CONNECTOR.               | Continental<br>Connector Co. | 15-16P            |
| J701                                | Same as J401.            |                              |                   |
| J801                                | RECORDER JACK.           | P. R. Mallory<br>& Co.       | 3B                |
| M801                                | METER (DEGREES)          | Maxson<br>Instruments        | C72955            |
| M802                                | METER (SENSE).           | Maxson<br>Instruments        | B72951            |
| M803                                | METER (UNKNOWN LEVEL).   | Maxson<br>Instruments        | B72949            |
| M804                                | METER (REFERENCE LEVEL). | Maxson<br>Instruments        | B72952            |
| M805                                | METER (BALANCE)          | Maxson<br>Instruments        | B72950            |
| P101                                | CONNECTOR.               | Continental<br>Connector Co. | 18-16S            |
| P201                                | CONNECTOR.               | Continental<br>Connector Co. | 10-16S            |

| CIRCUIT<br>REFERENCE<br>DESIGNATION | DESCRIPTION                                                            | MFR'S NAME                   | MFR'S<br>PART NO. |
|-------------------------------------|------------------------------------------------------------------------|------------------------------|-------------------|
| P301                                | Same as P201.                                                          |                              |                   |
| P401                                | CONNECTOR .                                                            | Continental<br>Connector Co. | 7-16S             |
| P501                                | Same as P201 .                                                         |                              |                   |
| P601                                | CONNECTOR .                                                            | Continental<br>Connector Co. | 15-16S            |
| P701                                | Same as P401.                                                          |                              |                   |
| R101                                | RESISTOR, fixed: wirewound;<br>655 ohms $\pm 1\%$ ; 1/2 watt .         | Mepco, Inc.                  | WM-3A             |
| R102                                | Same as R101.                                                          |                              |                   |
| R103                                | RESISTOR, fixed: wirewound;<br>680 ohms $\pm 1\%$ ; 1/2 watt.          | Mepco, Inc.                  | WM-3A             |
| R104                                | Same as R103.                                                          |                              |                   |
| R105                                | RESISTOR, fixed: composition;<br>11,000 ohms $\pm 5\%$ ; 1 watt.       | Allen Bradley Co.            | GB1135            |
| R106                                | RESISTOR, fixed: composition;<br>1,000 ohms $\pm 5\%$ ; 1/2 watt.      | Allen Bradley Co.            | EB1025            |
| R107                                | RESISTOR, fixed: composition;<br>10,000 ohms $\pm 5\%$ ; 1 watt.       | Allen Bradley Co.            | GB1035            |
| R108                                | RESISTOR, fixed: composition;<br>0.1 meg $\pm 5\%$ ; 1/2 watt.         | Allen Bradley Co.            | EB1045            |
| R109                                | RESISTOR, fixed: deposited carbon;<br>0.56 meg $\pm 1\%$ ; 1/2 watt.   | IRC                          | DCC               |
| R110                                | RESISTOR, fixed: deposited carbon;<br>1.0 meg $\pm 1\%$ ; 1/2 watt.    | IRC                          | DCC               |
| R111                                | RESISTOR, fixed: deposited carbon;<br>8,200 ohms $\pm 1\%$ ; 1/2 watt. | IRC                          | DCC               |
| R112                                | RESISTOR, fixed: composition;<br>0.47 meg $\pm 5\%$ ; 1/2 watt .       | Allen Bradley Co.            | EB4745            |

| CIRCUIT<br>REFERENCE<br>DESIGNATION | DESCRIPTION                                                         | MFR'S NAME           | MFR'S<br>PART NO. |
|-------------------------------------|---------------------------------------------------------------------|----------------------|-------------------|
| R113                                | RESISTOR, fixed: composition;<br>2, 200 ohms $\pm 5\%$ ; 1/2 watt.  | Allen Bradley<br>Co. | EB2225            |
| R114                                | Same as R112.                                                       |                      |                   |
| R115                                | Same as R113.                                                       |                      |                   |
| R116                                | Same as R110.                                                       |                      |                   |
| R117                                | Same as R111.                                                       |                      |                   |
| R118                                | Same as R109.                                                       |                      |                   |
| R119                                | RESISTOR, fixed: composition;<br>0.15 meg $\pm 5\%$ ; 1 watt.       | Allen Bradley<br>Co. | GB1545            |
| R120                                | Same as R119.                                                       |                      |                   |
| R121                                | Same as R110.                                                       |                      |                   |
| R122                                | RESISTOR, fixed: composition;<br>2, 700 ohms $\pm 5\%$ ; 1/2 watt.  | Allen Bradley<br>Co. | EB2735            |
| R123                                | Same as R113.                                                       |                      |                   |
| R124                                | Same as R113.                                                       |                      |                   |
| R125                                | Same as R110.                                                       |                      |                   |
| R126                                | Same as R122.                                                       |                      |                   |
| R127                                | Same as R106.                                                       |                      |                   |
| R128                                | Same as R106.                                                       | Allen Bradley<br>Co. | EB3315            |
| R129                                | RESISTOR, fixed: composition;<br>330 ohms $\pm 5\%$ ; 1/2 watt.     |                      |                   |
| R130                                | RESISTOR, fixed: composition;<br>2, 000 ohms $\pm 5\%$ ; 1/2 watt.  |                      |                   |
| R201                                | RESISTOR, fixed: composition;<br>47, 000 ohms $\pm 5\%$ ; 1/2 watt. | Allen Bradley<br>Co. | EB4735            |
| R202                                | RESISTOR, fixed: deposited<br>carbon 0.47 meg $\pm 1\%$ ; 1/2 watt. |                      |                   |
| R203                                | RESISTOR, fixed: composition;<br>0.51 meg $\pm 5\%$ ; 1 watt.       | Allen Bradley<br>Co. | GB5135            |
| R204                                | RESISTOR, fixed: composition;<br>0.20 meg $\pm 5\%$ ; 1/2 watt.     |                      |                   |
| R205                                | Same as R108.                                                       | Allen Bradley<br>Co. | EB2045            |

| CIRCUIT<br>REFERENCE<br>DESIGNATION | DESCRIPTION                                                          | MFR'S NAME                      | MFR'S<br>PART NO. |
|-------------------------------------|----------------------------------------------------------------------|---------------------------------|-------------------|
| R206                                | RESISTOR, fixed: composition;<br>0.12 meg $\pm$ 5%; 1/2 watt.        | Allen Bradley Co.               | EB1245            |
| R207                                | RESISTOR, fixed: deposited carbon;<br>0.27 meg $\pm$ 1%; 1/2 watt.   | International<br>Resistor Corp. | DCC               |
| R208                                | RESISTOR, fixed: deposited carbon;<br>0.1 meg $\pm$ 1%; 1/2 watt.    | International<br>Resistor Corp. | DCC               |
| R209                                | RESISTOR, fixed: deposited carbon;<br>1.0 meg $\pm$ 1%; 1/2 watt.    | International<br>Resistor Corp. | DCC               |
| R210                                | RESISTOR, fixed: deposited carbon;<br>2,700 ohms $\pm$ 1%; 1/2 watt. | International<br>Resistor Corp. | DCC               |
| R211                                | Same as R110.                                                        |                                 |                   |
| R212                                | RESISTOR, fixed: composition;<br>680 ohms $\pm$ 5%; 1/2 watt.        | Allen Bradley Co.               | EB6815            |
| R213                                | Same as R110.                                                        |                                 |                   |
| R214                                | RESISTOR, fixed: composition;<br>27,000 ohms $\pm$ 5%; 1/2 watt.     | Allen Bradley Co.               | EB2735            |
| R215                                | Same as R108.                                                        |                                 |                   |
| R216                                | Same as R110.                                                        |                                 |                   |
| R217                                | RESISTOR, fixed: composition;<br>22,000 ohms $\pm$ 5%, 1/2 watt.     | Allen Bradley Co.               | EB2235            |
| R218                                | Same as R110.                                                        |                                 |                   |
| R219                                | Same as R109.                                                        |                                 |                   |
| R220                                | Same as R101.                                                        |                                 |                   |
| R221                                | Same as R201.                                                        |                                 |                   |
| R222                                | Same as R202.                                                        |                                 |                   |
| R223                                | Same as R203.                                                        |                                 |                   |
| R223                                | Same as R203.                                                        |                                 |                   |
| R224                                | Same as R204.                                                        |                                 |                   |
| R225                                | Same as R100.                                                        |                                 |                   |
| R226                                | Same as R206.                                                        |                                 |                   |

| CIRCUIT<br>REFERENCE<br>DESIGNATION | DESCRIPTION                                                       | MFR'S NAME        | MFR'S<br>PART NO. |
|-------------------------------------|-------------------------------------------------------------------|-------------------|-------------------|
| R227                                | Same as R208.                                                     | Allen Bradley Co. | EB6855            |
| R228                                | Same as R209.                                                     |                   |                   |
| R229                                | Same as R210.                                                     |                   |                   |
| R230                                | Same as R207.                                                     |                   |                   |
| R231                                | RESISTOR, fixed: composition;<br>6.8 meg $\pm$ 5%, 1/2 watt.      |                   |                   |
| R232                                | Same as R110.                                                     |                   |                   |
| R233                                | Same as R212.                                                     |                   |                   |
| R234                                | Same as R110.                                                     |                   |                   |
| R235                                | Same as R214.                                                     |                   |                   |
| R236                                | Same as R108.                                                     |                   |                   |
| R237                                | Same as R110.                                                     |                   |                   |
| R238                                | Same as R217.                                                     |                   |                   |
| R239                                | Same as R110.                                                     |                   |                   |
| R240                                | Same as R109.                                                     |                   |                   |
| R241                                | Same as R109.                                                     |                   |                   |
| R301                                | RESISTOR, fixed: deposited carbon;<br>1.0 meg $\pm$ 1%, 1/2 watt. | IRC               | DCC               |
| R302                                | RESISTOR, fixed: composition;<br>200 ohms $\pm$ 5%; 1/2 watt.     | Allen Bradley Co. | EB2015            |
| R303                                | Same as R214.                                                     | Allen Bradley Co. | GB6835            |
| R304                                | RESISTOR, fixed: composition;<br>68,000 ohms $\pm$ 5%; 1 watt.    |                   |                   |
| R305                                | Same as R122.                                                     |                   |                   |
| R306                                | Same as R110.                                                     |                   |                   |
| R307                                | Same as R110.                                                     |                   |                   |
| R308                                | Same as R301.                                                     |                   |                   |
| R309                                | Same as R302.                                                     |                   |                   |

| CIRCUIT<br>REFERENCE<br>DESIGNATION | DESCRIPTION                                                                 | MFR'S NAME            | MFR'S<br>PART NO. |
|-------------------------------------|-----------------------------------------------------------------------------|-----------------------|-------------------|
| R310                                | Same as R303 .                                                              | Maxson<br>Instruments | B72958            |
| R311                                | Same as R122 .                                                              |                       |                   |
| R312                                | Same as R110 .                                                              |                       |                   |
| R313                                | Same as R110 .                                                              |                       |                   |
| R314                                | Same as R304 .                                                              |                       |                   |
| R315A<br>R315B                      | RESISTOR, fixed: wire- matched<br>wound; 5000 ohms $\pm 1\%$ to $\pm .01\%$ |                       |                   |
| R317                                | Same as R110 .                                                              |                       |                   |
| R318                                | Same as R122 .                                                              |                       |                   |
| R319                                | Same as R304 .                                                              |                       |                   |
| R320                                | RESISTOR, fixed: composition;<br>5100 ohms $\pm 5\%$ ; 1 watt .             | Allen Bradley Co.     | GB5125            |
| R321                                | Same as R108 .                                                              |                       |                   |
| R322                                | Same as R107 .                                                              |                       |                   |
| R323                                | Same as R106 .                                                              |                       |                   |
| R324                                | Same as R105 .                                                              |                       |                   |
| R325                                | Same as R106 .                                                              |                       |                   |
| R326                                | Same as R106 .                                                              |                       |                   |
| R327                                | Same as R110 .                                                              |                       |                   |
| R328                                | Same as R110 .                                                              |                       |                   |
| R329                                | RESISTOR, fixed: composition;<br>150 ohms $\pm 5\%$ ; 1/2 watt              | Allen Bradley Co.     | EB1515            |
| R330                                | Same as R329 .                                                              |                       |                   |
| R331                                | RESISTOR, fixed: composition;<br>4,700 ohms $\pm 5\%$ ; 1 watt .            | Allen Bradley Co.     | GB4725            |
| R332                                | Same as R331 .                                                              |                       |                   |
| R401                                | Same as R110 .                                                              |                       |                   |
| R402                                | Same as R106 .                                                              |                       |                   |

| CIRCUIT<br>REFERENCE<br>DESIGNATION | DESCRIPTION                                                         | MFR'S NAME        | MFR'S<br>PART NO. |
|-------------------------------------|---------------------------------------------------------------------|-------------------|-------------------|
| R403                                | RESISTOR, fixed: composition;<br>5,600 ohms $\pm 5\%$ ; 1/2 watt.   | Allen Bradley Co. | EB5625            |
| R404                                | Same as R403.                                                       |                   |                   |
| R405                                | Same as R110.                                                       |                   |                   |
| R406                                | Same as R106.                                                       |                   |                   |
| R407                                | RESISTOR, fixed: composition;<br>110,000 ohms $\pm 5\%$ ; 1/2 watt. | Allen Bradley Co. | EB11045           |
| R408                                | Same as R407                                                        |                   |                   |
| R501                                | Same as R110.                                                       |                   |                   |
| R502                                | Same as R106.                                                       |                   |                   |
| R503                                | RESISTOR, fixed: composition;<br>510 ohms $\pm 5\%$ ; 1/2 watt.     | Allen Bradley Co. | EB5115            |
| R504                                | Same as R320.                                                       |                   |                   |
| R505                                | Same as R106.                                                       |                   |                   |
| R506                                | Same as R208.                                                       |                   |                   |
| R507                                | Same as R119.                                                       |                   |                   |
| R508                                | Same as R113.                                                       |                   |                   |
| R509                                | Same as R112.                                                       |                   |                   |
| R510                                | RESISTOR, fixed: composition;<br>1500 ohms $\pm 5\%$ ; 1/2 watt.    |                   |                   |
| R511                                | RESISTOR, fixed: composition;<br>8.2 meg $\pm 5\%$ ; 1/2 watt.      |                   |                   |
| R512                                | Same as R110.                                                       | Allen Bradley Co. | EB1525            |
| R513                                | RESISTOR, fixed: composition;<br>0.16 meg $\pm 5\%$ ; 1 watt.       |                   |                   |
| R514                                | RESISTOR, fixed: composition;<br>820 ohms $\pm 5\%$ ; 1/2 watt.     | Allen Bradley Co. | EB8215            |
| R515                                | Same as R112.                                                       |                   |                   |
| R516                                | RESISTOR, fixed: composition;<br>300,000 $\pm 5\%$ ; 1/2 watt.      | Allen Bradley Co. | EB30045           |
| R517                                | Same as R106.                                                       |                   |                   |

| CIRCUIT<br>REFERENCE<br>DESIGNATION | DESCRIPTION                                                        | MFR'S NAME        | MFR'S<br>PART NO. |
|-------------------------------------|--------------------------------------------------------------------|-------------------|-------------------|
| R518                                | Same as R106.                                                      | Allen Bradley Co. | HB4735            |
| R519                                | Same as R106.                                                      |                   |                   |
| R520                                | Same as R106.                                                      |                   |                   |
| R521                                | RESISTOR, fixed: composition;<br>47,000 ohms $\pm 5\%$ ; 2 watts.  |                   |                   |
| R522                                | RESISTOR, fixed: composition;<br>10,000 ohms $\pm 5\%$ ; 1/2 watt. |                   |                   |
| R601                                | Same as R110.                                                      | Allen Bradley Co. | EB1035            |
| R602                                | Same as R320.                                                      |                   |                   |
| R603                                | Same as R503.                                                      |                   |                   |
| R604                                | Same as R107.                                                      |                   |                   |
| R605                                | Same as R108.                                                      |                   |                   |
| R606                                | Same as R503.                                                      |                   |                   |
| R607                                | Same as R107.                                                      |                   |                   |
| R608                                | Same as R130.                                                      |                   |                   |
| R609                                | Same as R106.                                                      |                   |                   |
| R610                                | Same as R106.                                                      |                   |                   |
| R611                                | Same as R122.                                                      |                   |                   |
| R612                                | Same as R122.                                                      |                   |                   |
| R613                                | Same as R110.                                                      |                   |                   |
| R614                                | Same as R110.                                                      |                   |                   |
| R615                                | Same as R112.                                                      |                   |                   |
| R616                                | Same as R112.                                                      |                   |                   |
| R617                                | Same as R109.                                                      |                   |                   |
| R618                                | Same as R109.                                                      |                   |                   |
| R619                                | Same as R302.                                                      |                   |                   |
| R620                                | Same as R110.                                                      |                   |                   |

| CIRCUIT<br>REFERENCE<br>DESIGNATION | DESCRIPTION                                                     | MFR'S NAME            | MFR'S<br>PART NO.  |
|-------------------------------------|-----------------------------------------------------------------|-----------------------|--------------------|
| R621                                | Same as R110.                                                   | Allen Bradley Co.     | GB6225             |
| R622                                | Same as R106.                                                   |                       |                    |
| R623                                | Same as R106.                                                   |                       |                    |
| R701                                | Same as R110.                                                   |                       |                    |
| R702                                | Same as R110.                                                   |                       |                    |
| R703                                | Same as R503.                                                   |                       |                    |
| R704                                | Same as R503.                                                   |                       |                    |
| R705                                | RESISTOR, fixed: composition;<br>6200 ohms $\pm 5\%$ ; 1 watt.  |                       |                    |
| R706                                | Same as R705.                                                   |                       |                    |
| R707                                | Same as R106.                                                   |                       |                    |
| R708                                | Same as R106.                                                   |                       |                    |
| R801                                | POTENTIOMETER: 50 ohms,<br>2 watts.                             | Allen Bradley Co.     | JU-5001-P<br>3040  |
| R802                                | POTENTIOMETER:<br>5,000 ohms; 2 watts.                          | Allen Bradley Co.     | JU-5021-<br>SD3040 |
| R803                                | RESISTOR, fixed: composition;<br>100 ohms $\pm 5\%$ ; 1/2 watt. | Allen Bradley Co.     | EB1015             |
| R804                                | RESISTOR, fixed: wirewound;<br>26.0 ohms $\pm 1\%$ ; 1/2 watt   | Mepco, Inc.           | WM3A               |
| R805                                | POTENTIOMETER:<br>5,000 ohms; 1/2 watt                          | Clarostat Mfg.<br>Co. | A47-5k             |
| R806                                | Same as R805.                                                   | Clarostat Mfg.<br>Co. | 58-20K             |
| R807                                | POTENTIOMETER: wirewound;<br>20,000 ohms.                       |                       |                    |
| R809                                | Same as R201.                                                   |                       |                    |
| R810                                | Same as R201.                                                   | Allen Bradley Co.     | JU-1041-<br>P3040  |
| R811                                | POTENTIOMETER:<br>50,000 ohms; 2 watts.                         |                       |                    |

| CIRCUIT<br>REFERENCE<br>DESIGNATION | DESCRIPTION                                                              | MFR'S NAME                      | MFR'S<br>PART NO. |
|-------------------------------------|--------------------------------------------------------------------------|---------------------------------|-------------------|
| R812                                | ATTENUATOR, variable:<br>12, 000 ohms.                                   | Maxson<br>Instruments           | B72982            |
| R813                                | Same as R514.                                                            |                                 |                   |
| R814                                | ATTENUATOR, fixed:<br>450 ohms.                                          | Maxson<br>Instruments           | B72983            |
| R815                                | RESISTOR, fixed: composition;<br>33 ohms $\pm 5\%$ ; 1/2 watt.           | Allen Bradley Co.               | EB3305            |
| R816                                | Same as R801.                                                            |                                 |                   |
| R817                                | Same as R812.                                                            |                                 |                   |
| R818                                | RESISTOR, fixed: composition;<br>560 ohms $\pm 5\%$ ; 1/2 watt.          | Allen Bradley Co.               | EB5615            |
| R819                                | Same as R814.                                                            |                                 |                   |
| R820                                | Same as R815.                                                            |                                 |                   |
| R821                                | Same as R801.                                                            |                                 |                   |
| R824                                | Part of Z801.                                                            |                                 |                   |
| R825                                | RESISTOR, fixed: deposited carbon;<br>11, 000 ohms $\pm 1\%$ ; 1/2 watt. | International<br>Resistor Corp. | DCC               |
| R826                                | RESISTOR, fixed: deposited carbon;<br>120, 000 ohms $\pm 1\%$ 1/2 watt   | International<br>Resistor Corp. | DCC               |
| R827                                | Same as R825.                                                            |                                 |                   |
| S801                                | SWITCH, DPDT: rotary toggle.                                             | Arrow, Hart,<br>& Hegeman, Inc. | 81727             |
| S802                                | SWITCH, selector.                                                        | Maxson<br>Instruments           | C72974            |
| S803                                | Same as S801.                                                            |                                 |                   |
| S804                                | SWITCH.                                                                  | Maxson<br>Instruments           | C72973            |
| S807                                | Same as S801.                                                            |                                 |                   |
| S808                                | SWITCH: part of R806.                                                    | Clarostat Mfg.<br>Co.           | SWE-21            |
| S809                                | SWITCH: part of R805.                                                    | Clarostat Mfg.<br>Co.           | SWE-21            |

| CIRCUIT<br>REFERENCE<br>DESIGNATION | DESCRIPTION             | MFR'S NAME            | MFR'S<br>PART NO. |
|-------------------------------------|-------------------------|-----------------------|-------------------|
| T101                                | TRANSFORMER.            | Maxson<br>Instruments | C72984            |
| T601                                | Same as T101.           |                       |                   |
| T701                                | TRANSFORMER.            | Maxson<br>Instruments | A9-001-32         |
| T702                                | Same as T701.           |                       |                   |
| V101                                | QUAD DIODE              | Maxson<br>Instruments | A9-001-19         |
| V102                                | ELECTRON TUBE: 5751     |                       |                   |
| V103                                | Same as V102.           |                       |                   |
| V104                                | Same as V102.           |                       |                   |
| V105                                | ELECTRON TUBE: 12AT7WA. |                       |                   |
| V201                                | Same as V102.           |                       |                   |
| V202                                | ELECTRON TUBE: 6AU6WA.  |                       |                   |
| V203                                | Same as V102.           |                       |                   |
| V204                                | Same as V102.           |                       |                   |
| V205                                | Same as V202.           |                       |                   |
| V206                                | Same as V102.           |                       |                   |
| V207                                | Same as V102.           |                       |                   |
| V301                                | Same as V102.           |                       |                   |
| V302                                | Same as V102.           |                       |                   |
| V303                                | Same as V102.           |                       |                   |
| V304                                | Same as V102.           |                       |                   |
| V305                                | Same as V102.           |                       |                   |
| V306                                | Same as V105.           |                       |                   |
| V401                                | ELECTRON TUBE: 12AT7-WA |                       |                   |

| CIRCUIT<br>REFERENCE<br>DESIGNATION | DESCRIPTION                            | MFR'S NAME                  | MFR'S<br>PART NO. |
|-------------------------------------|----------------------------------------|-----------------------------|-------------------|
| V402                                | Same as V401.                          | Victoreen<br>Instrument Co. |                   |
| V501                                | Same as V105.                          |                             |                   |
| V502                                | Same as V102.                          |                             |                   |
| V503                                | Same as V202.                          |                             |                   |
| V504                                | Same as V105.                          |                             |                   |
| V505                                | Same as V105.                          |                             |                   |
| V506                                | VOLTAGE REGULATOR TUBE: VR-57          |                             |                   |
| V601                                | Same as V105.                          |                             |                   |
| V602                                | Same as V102.                          |                             |                   |
| V603                                | Same as V105.                          |                             |                   |
| V701                                | Same as V105.                          | Maxson<br>Instruments       | D72962            |
| Z801                                | PRECISION VOLTAGE DIVIDER<br>ASSEMBLY. |                             |                   |

## POWER SUPPLY CHASSIS

| CIRCUIT<br>REFERENCE<br>DESIGNATION | DESCRIPTION                                                       | MFR'S NAME                   | MFR'S<br>PART NO.  |
|-------------------------------------|-------------------------------------------------------------------|------------------------------|--------------------|
| C901-A                              | CAPACITOR, electrolytic, dual<br>8 uf; 450 v d-c.                 | Sprague Electric<br>Co.      | D30666-930         |
| C901-B                              | Same as C901-A.                                                   |                              |                    |
| C902                                | CAPACITOR, Electrolytic,<br>160 uf; 450 v d-c.                    | Sprague Electric<br>Co.      | D30665-930         |
| C903                                | CAPACITOR, ceramic, 10 uuf;<br>600 v d-c.                         | Erie Ceramison               | Cat. No.<br>TCO-10 |
| C904                                | CAPACITOR, paper, 0.1 uf;<br>600 v d-c.                           | Sprague Electric<br>Co.      | 91P1049654         |
| C905                                | CAPACITOR, paper, 1.0 uf;<br>600 v d-c.                           | Sprague Electric<br>Co.      | CP55B1EF105        |
| C906                                | Same as C902.                                                     |                              |                    |
| CR901<br>thru<br>CR914              | DIODE, silicon, rectifier.                                        | RCA                          | 1N 1764            |
| F901                                | FUSE: 0.2 ampere.                                                 | Bussmann Mfg.                | MDL                |
| F902                                | FUSE: 1/2 ampere.                                                 | Bussmann Mfg.                | MDL                |
| F903                                | FUSE: 3.0 amperes.                                                | Bussmann Mfg.                | MDX                |
| I901                                | LAMP, 28 volts.                                                   |                              | 313                |
| J901                                | CONNECTOR.                                                        | Amphenol                     | 61-M10             |
| P902                                | CONNECTOR.                                                        | Continental<br>Connector Co. | 7-168              |
| R901                                | RESISTOR, fixed: composition;<br>470,000 ohms $\pm 5\%$ ; 1 watt  | Allen Bradley Co.            | GB4745             |
| R902                                | RESISTOR, wirewound, 2500<br>ohms, $\pm 5\%$ ; 20 watt.           | Ward Leonard                 | 10F2500WL          |
| R903                                | Same as R902.                                                     |                              |                    |
| R904                                | RESISTOR, fixed: composition;<br>330,000 ohms $\pm 5\%$ ; 1 watt. | Allen Bradley Co.            | GB3345             |
| R905                                | RESISTOR, fixed: composition;<br>150 ohms $\pm 5\%$ ; 1 watt      | Allen Bradley Co.            | GB1515             |

| CIRCUIT<br>REFERENCE<br>DESIGNATION | DESCRIPTION                                                              | MFR'S NAME                      | MFR'S<br>PART NO. |
|-------------------------------------|--------------------------------------------------------------------------|---------------------------------|-------------------|
| R906                                | Same as R905.                                                            |                                 |                   |
| R907                                | Same as R905.                                                            |                                 |                   |
| R908                                | RESISTOR, Fixed: composition;<br>39 ohms $\pm 5\%$ ; 1 watt.             | Allen Bradley Co.               | GB3905            |
| R909                                | Same as R908.                                                            |                                 |                   |
| R910                                | Same as R908.                                                            |                                 |                   |
| R911                                | RESISTOR, fixed: composition;<br>330 ohms $\pm 5\%$ ; 1/2 watt.          | Allen Bradley Co.               | EB3315            |
| R912                                | Same as R911.                                                            |                                 |                   |
| R913                                | Same as R911.                                                            |                                 |                   |
| R914                                | RESISTOR, fixed: composition<br>10,000 ohms, $\pm 5\%$ ; 1 watt.         | Allen Bradley Co.               | GB1035            |
| R915                                | RESISTOR, fixed: composition;<br>4700 ohms $\pm 5\%$ ; 1 watt.           | Allen Bradley Co.               | GB4725            |
| R916                                | RESISTOR, fixed: deposited carbon;<br>1 meg $\pm 1\%$ ; 1/2 watt.        | International<br>Resistor Corp. | DCC               |
| R917                                | RESISTOR, fixed: deposited carbon;<br>220,000 ohms $\pm 1\%$ ; 1/2 watt. | International<br>Resistor Corp. | DCC               |
| R918                                | RESISTOR, wirewound, low drift;<br>60,000 ohms $\pm 5\%$ ; 20 watt.      | Ward Leonard                    | T60000 WL         |
| R919                                | RESISTOR, wirewound, 25,000<br>ohms, $\pm 5\%$ ; 10 watt.                | Ward Leonard                    | 10F25000 WL       |
| R920                                | RESISTOR, wirewound, 13,500<br>$\pm 5\%$ ; 10 watt.                      | Ward Leonard                    | 10F13500 WL       |
| R921                                | RESISTOR, potentiometer,<br>wirewound, 5000 ohms $\pm 10\%$ ;<br>2 watt. | International<br>Resistor Corp. | WPPL 5000         |
| R922                                | RESISTOR, fixed: composition;<br>20,000 ohms $\pm 5\%$ ; 2 watt.         | Allen Bradley Co.               | RC42GF203J        |
| S901                                | SWITCH, toggle; term. type "L";<br>15A; 125V.                            | Cutler-Hammer                   | SPST No. 7501     |
| T901                                | TRANSFORMER, power.                                                      | Signal Transformer<br>Co.       | 3406C             |

| CIRCUIT<br>REFERENCE<br>DESIGNATION | DESCRIPTION                              | MFR'S NAME       | MFR'S<br>PART NO. |
|-------------------------------------|------------------------------------------|------------------|-------------------|
| TB901                               | TERMINAL STRIP                           | Cinch Mfr. Corp. | 7-141-Y           |
| V901                                | ELECTRON TUBE: OD3                       |                  |                   |
| V902                                | ELECTRON TUBE: 5881                      |                  |                   |
| V903                                | Same as V902                             |                  |                   |
| V904                                | Same as V902                             |                  |                   |
| V905                                | ELECTRON TUBE: OB2WA                     |                  |                   |
| V906                                | ELECTRON TUBE: 5651,<br>Amperex OR5651WA |                  |                   |
| V907                                | ELECTRON TUBE: 6AU6                      |                  |                   |
| V908                                | ELECTRON TUBE: 12AX7                     |                  |                   |





